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Applied Science

INCORPORATED WITH

TRANSACTIONS OF THE UNIVERSITY OF TORONTO ENGINEERING SOCIETY

Old Series Vol. 27 TORONTO, MAY., 1915 New Series Vol. X. No. 1

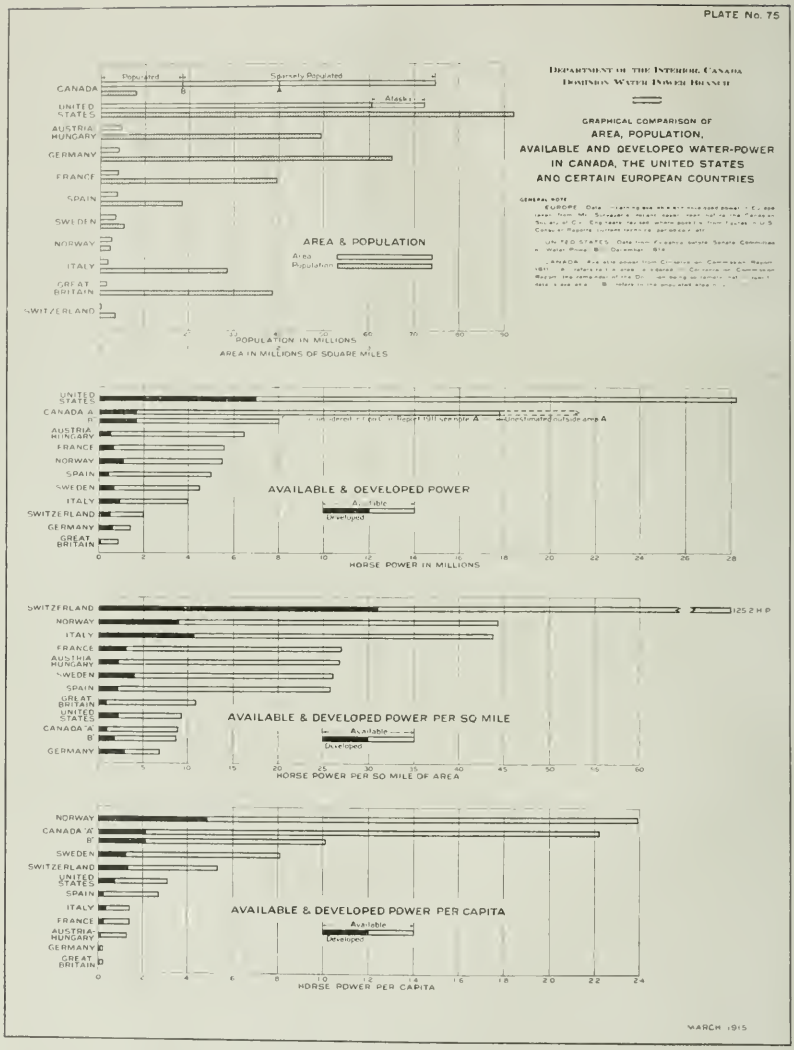
THE WATER POWER SITUATION IN CANADA

Exceedingly Advantageous Location of our Falls—Greatest Per Capita Development Except Norway—Greatest Total Available Except United States.

By J. B. Challies, '03, M. Can. Soc. C.E.
Superintendent, Dominion Water Power Branch

A survey of the water power situation in the different countries of the world shows that Canada, the youngest of them all, has accomplished more in actual development and in use, than any except, perhaps, Norway. The outstanding feature of the power situation in Canada is the exceedingly fortunate and advantageous location of our water powers from the Atlantic to the Pacific. Practically every large city is to-day supplied with all the hydro-electric energy it can use from water power, the sources of which can be extended to meet all anticipated demands. Where the source of power is not water power, as in the middle western prairies, there is an abundance of either gas or good steam coal within immediate reach. There is probably no part of the present settled portions of the Dominion where power cannot profitably be produced from wholly Canadian sources. In cases of necessity we can be, and in time we shall be, independent of all foreign power-producing agencies.

All substantial and reasonably necessary power requirements throughout Canada have been met and provided for, and much pioneer work has been accomplished in adapting hydro-electric energy to new and highly profitable industrial use. In fact, the water power situation strikingly demonstrates the faith of Canadians in our vast heritage. We have been extending an ever-widening net-work of transmission lines over our far-flung territories so that to-day, measured by population, we have the highest ratio of water horse-power of any other nation except Norway. On the other hand, as suggesting the room still left for expansion, we have the lowest ratio of water horsepower in proportion to area. The progress of power development in Canada has, so far, been based on sound engineering and sure economic principles, and there have, therefore, been very few financial failures. This has resulted in the



The Water Power Situation in Canada and other Countries

popular delusion of the great potential value of undeveloped water powers, and in some districts in the general public being unduly apprehensive of the profits and powers of public utility corporations which control or develop existing water powers.

The great importance of our power resources, their successful adaptation for industrial use and for furnishing so much of our modern comfort, has resulted in the general public taking a very marked interest in all questions pertaining to water power administration, investigation and use, and the question of suitable legislation covering water power administration and authorization has become one of the most important legislative topics in Canada.

On the whole we are exceedingly fortunate in Canada, especially when we compare our conditions with those of the United States. Our water power laws are, in the main, quite adequate; encouraging to development with due regard to the public interest, present and future. While in some parts of Canada we may have outgrown former conditions and in such parts governmental machinery and laws with respect to water powers have not advanced as fast as might be desired, it must be remembered that there is but a short distance in time from the 50 h.p. overshot mill wheel of small efficiency and crude apparatus of local use and of little general importance to the community at large, to the 20,000 h.p. turbine of over 90 per cent. efficiency and 200 mile transmission line of to-day, of such widespread importance owing to the present universality of the electrical industry. In a very short time it is probable that legislators in all parts of the Dominion will have realized the advantage of and have put into force an efficient water power administration providing reasonable laws under which water power development will be fostered with due protection to the public interest.

In the lull which has temporarily supervened in power development in Canada, we can look back with satisfaction upon a long period of uninterrupted prosperity and marvellous expansion. This lull should enable the Dominion and Provincial Government Department, interested in water power matters to perfect their arrangements for securing that physical and economic data which is always essential and a necessary preliminary to the financing of new water power developments.

While in the past there has been a great lack of reliable data regarding Canadian water powers, there is now much excellent work under way throughout the Dominion which if continued and extended without delay, will result in sufficient data being obtained regarding all powers within transmission radius of present or prospective commercial centres being available for consideration when the present financial stringency is relieved.

It has been said that the use of power in Canada for electro-chemistry, electro-metallurgy, and electro-siderurgy, has not kept pace with the advance made in these arts in other countries, and on the other hand that certain European countries are using about one-half of their developed water powers for these latter purposes. It must be admitted that most of the developed power in Canada is

used for motive power, traction and lighting, and but a small percentage for electro-chemistry, electro-metallurgy, and electro-siderurgy. This condition of affairs is probably the result of a young country first, meeting its most urgent permanent and "primitive" power requirements, that is, for lighting, traction and motive purposes, and to temporarily postpone the extensive and intensive adaptation of power for electro-chemical and electro-metallurgical purposes; at any rate until adverse economic conditions and financial hazards surrounding the use of power for such purposes have been overcome. One thing certain, no country in the world has realized greater benefit from the advantages of hydro-electric power for domestic, municipal and manufacturing purposes, than have the people of the Province of Ontario, thanks to the Hydro-Electric Power Commission of Ontario.

In a general way any considerable extension to existing power plants and the development of additional water powers in Canada must depend primarily upon the demand for power from traction, lighting, and motive power sources, and but secondarily on the possible use of power for electro-chemical, electro-metallurgical, and electro-siderurgical purposes; of course the use of power for pulp-making alone excepted. Unless we use our power to supply the ever-increasing demand from our southern neighbors in the United States, the first use of power will grow directly with the increase in our population, slowly and steadily at any rate for the next decade. For any considerable increase in our present power demand, except power required for pulp-making, we must depend largely on proving the commercial possibilities of the use of power for electro-chemical and electro-metallurgical purposes.

SHELL MANUFACTURE IN A GENERAL ENGINEERING PLANT*

Perhaps the most fortunate of the various manufacturing institutions in its ability to readily take over the shell business is the general engineering plant. The equipment usually requires comparatively slight alteration, and there are also at hand the type of men and scope for designing and building any necessary special apparatus at short notice

The unexpected change of employment of the greater number of Canada's metal working plants from the production of articles of peaceful commerce to the fabrication of munitions of war has been done at more or less sacrifice depending largely upon the character of the plant. The methods herein described for the manufacture of shrapnel shells are those adopted by a plant whose regular equipment is unusually well suited to the different processes involved. The product for which original machines were installed consists of internal combustion engines in large quantities, and it will be interesting to note the great similarity in the various operations required to those of the more warlike output at present being produced.

* From Canadian Machinery, Toronto.

The shells are received at the plant from the steel works in the form of rough forgings. They are unloaded from the cars in a well equipped shipping department on to an auto-car operating on an industrial railway and by means of which they are transported to the shell department beside the machines which perform the first operation—the trimming of the open end. These include a cutting-off machine with two tools and variable feed, a John Hall & Sons Brantford pipe machine and a heavy standard lathe. The gauging point for this as well as subsequent operations is the bottom of the shell chamber inside.

Use of Milling Machines

The basing or rough facing of the closed ends is done most efficiently upon an Ingersoll four-spindle milling machine, using the

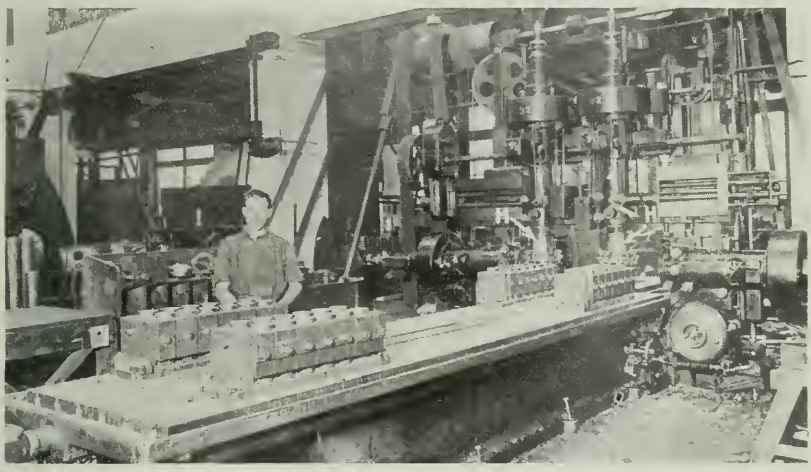


Fig. 1. Continuous Milling of Bases on Ingersoll Multiple Spindle Machine

two vertical spindle heads. The plates of the machine carries four fixtures located in pairs near either end. These fixtures hold twelve shells each, arranged in two rows of six. The shell is simply dropped over a vertical gauge pin and is clamped, two shells to a clamp in an upright position.

The milling is done by two large, inserted tooth high speed steel facing cutters, one traversing each fixture. While one pair of fixtures is under the cutters, the operator is engaged, at the other end of the table, in emptying and reloading the other pair of fixtures so that the milling process is practically continuous. This has proved a most satisfactory method of doing this part of the work as the machine is powerful and rigid enough to work the high speed steel cutters to their capacity. Another machine of this type is being fitted up and will be in operation shortly.

After gauging for length, the forgings go to the various machines

utilized for the outside turning. For this purpose the shells are driven upon mandrels solidly attached to the face plates of the machines. These arbors are solid and are fitted, upon the shank part, with a circular nut. When it is desired to remove the work, this nut is simply tightened against it and a tap with a hammer upon the side serves to release it instantly.

The turning is done on two Bertram and two Bullard vertical turning and boring mills, one Conradson turret lathe, one Gisholt, two heavy Steinle turret lathes and one Pratt & Whitney turret lathe. The Steinle machines are equipped with a special expanding arbor and are used to turn such shell forgings as come slightly large so that they cannot be tightly driven on the solid arbors. The gripping points consist of twelve pins in four circles of three each

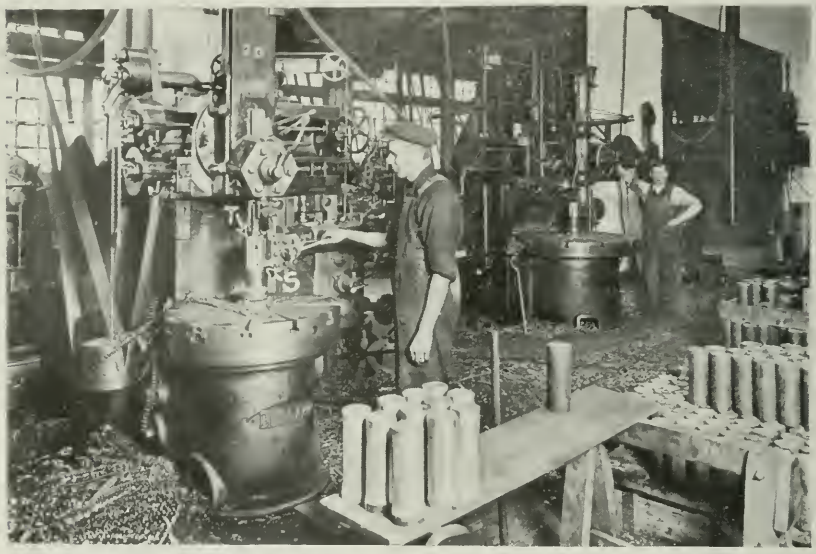


Fig. 2. Rough Turning Shell Forgings on Bullard and Bertram Vertical Turrets

which are moved outwards against the shell chamber by the wedge action of the spindle which is actuated by a nut at the rear end.

It is interesting to note that, in quantity of production, the competition between the several machines is rather close, the Steinles coming first, the Pratt & Whitney second and the vertical boring mills third, although the difference does not amount to more than from six to a dozen per day.

The series of operations consists of rough turning the shell body, finish turning from the band to the base, finish facing the base and roughing out the groove for the band. The work on the groove here consists of cutting down the whole width to the top of the vees of the wave and of cutting down the two edges to the bottom

of the vees. The rough turning of the body is carried up to the edge of the part which is nosed in, or, in other words, it involves the cylindrical part of the shell.

Boring Processes

The next operation consists in boring the shell in the bottom to receive the powder cup and also for the seat of the steel diaphragm which separates the powder from the bullets. This is also carried out on a number of machines of a widely varying nature. These include a Conradson turret lathe, a four-spindle Foote-Burt drilling machine, a Bertram horizontal boring machine, and others. At first sight, the latter machine appears extremely clumsy, and heavy

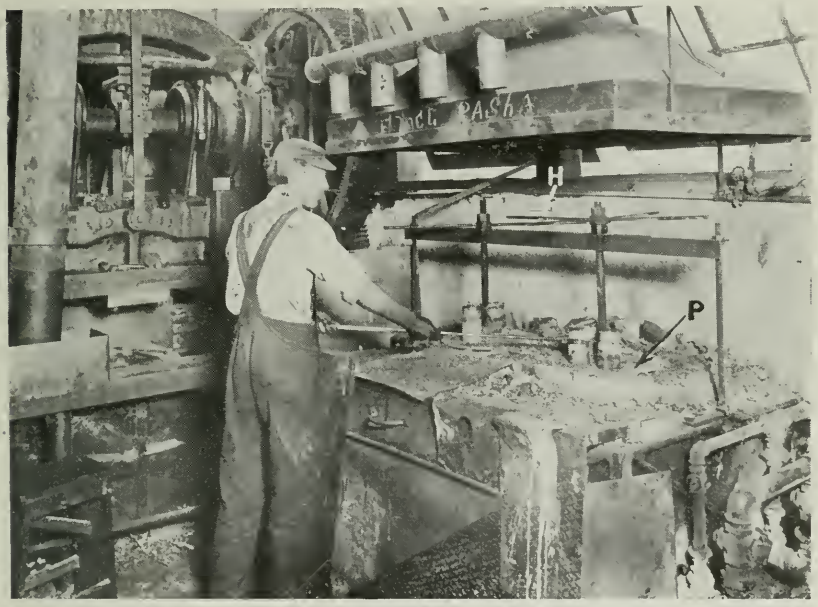


Fig. 3. Nose-heating Furnace and Nosing Press

for such work, but such has not actually proved to be the case. The rigidity of the machine and the abundance of driving power make up for a great amount of inconvenience and, what was at first a mere attempt to get something out of the machine and to keep it going has proved to be one of the best single spindles on the job, an output of 90 shells being obtained per eleven hours.

The multiple spindle drill, while being a very satisfactory machine in point of simplicity of operation and quantity of output, cannot be readily arranged to do the facing of the end; this, however, is done on a small machine not large enough to do the boring. The boring tools used consist of two solid bars equipped with flat formed cutters, one for roughing and one for finishing. These cutters or

bits possess the advantage of being easily made in numbers, and dull cutters can be quickly replaced by sharp ones without materially interfering with the progress of the work. The Foote-Burt machine operates two roughing and two finishing spindles continuously and is handled by two men.

The next operation is that of waving. This consists of turning in the bottom of the groove for the copper band a pair of inverted vees to prevent the band from turning on the shell as it traverses the length of the gun, so called because the vees are cut, not on a flat but on an undulating plane. The waving is accomplished by a square nosed tool with two vees of the correct dimensions cut in the face of it.

An interesting tool making question here arises as in order that the angle of the vee be correct on the sloping parts of the wave, the

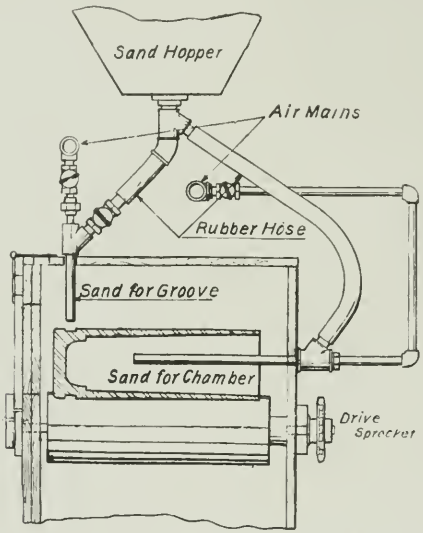


Fig. 4. Detail of Sand Blasting Machine

angle of the groove in the tool must be greater. The lateral oscillating motion is given to the tool by a face cam fastened to the face plate of the lathe. The work is done on two R. McDougall and two Bertram geared head lathes, equipped with special centering chucks which grip the work by the turned body The cam roller is fastened rigidly to the lathe carriage and is held to the face of the cam by a suitable weight. After waving, the open ends are turned for heading on a small lathe by hand feed the purpose being simply to true up this part of the shell, and only enough is taken off to accomplish this.

Heat Treatment

The shells come to this department placed on end in large trays, open ends up, each tray holding 120. A boy now paints

the bases and grooves of the shells with a mixture of whiting and alcohol to prevent oxidation of the finished parts during heating, and returns them to the tray closed ends up. For heating the shells, six lead baths are employed, the warming and final heating taking place in separate baths. These pots are heated by oil burners and the temperature regulation is maintained by electric pyrometers. The work is heated for about half its length, and, to accomplish this, it is held in a vertical position by the circular cover plate of the bath which contains four suitable perforations to receive the shells which are held down by a conveniently placed weight.

The hardening is accomplished by dipping in oil, three tanks approximately 4 ft. by 2½ ft. by 2 ft. being used. The dipping

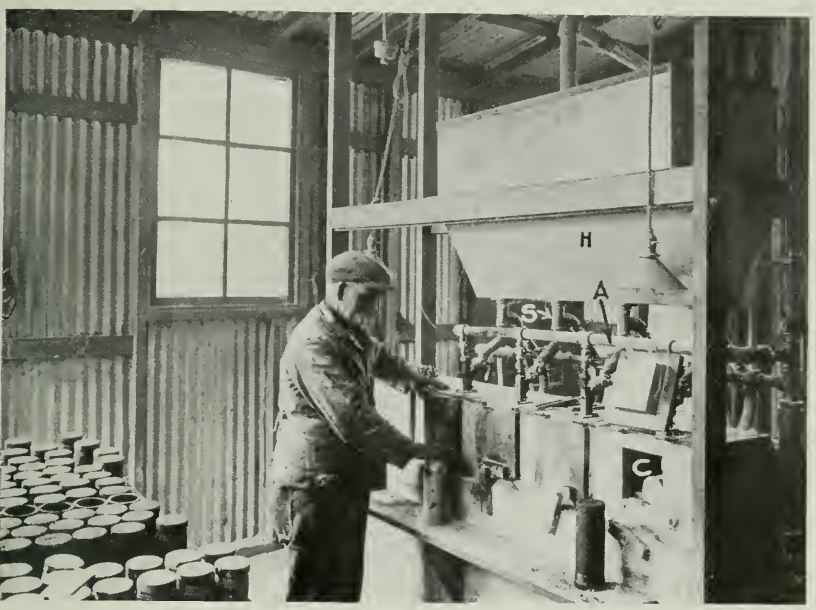


Fig. 5. Sand Blasting Machine which cleans Powder Chamber and Band Groove

is done with the open end of the shell entering the oil at an angle of about 45 degrees and is quickly reversed so that the base turns downwards. After chilling the shells are inverted upon hooks placed at the back of the tank to drain and are subsequently removed, cleaned and tested for hardness. For this, the well known scleroscope is used. The test must be applied at a specified distance from the end of the shell and at least three points in its circumference. A feature of the use of the scleroscope for this work is the rapid wear of the bulbs. Unless the very best quality is obtained these wear out at the rate of about one per day.

The next step in the process is sand blasting the groove and the inside or powder chamber. This is accomplished by means of a

very simple and most ingenious machine, devised and built by the Canadian Fairbanks-Morse Co. The apparatus consists of four compartments each just large enough to accommodate a shell and is closed by a wooden door. The shell rests upon a pair of live rollers so that it rotates continuously. One nozzle enters the open end and directs its flow of sand at the internal surfaces to be cleaned while another in a vertical position cleans the groove and its undercutting. There are, of course, four pairs of nozzles and the process is completed as fast as one man can handle the shells.

The forming of the nose is done on a heavy geared stamping and forming press. The furnaces used here are worthy of note. These are the usual oil heated lead baths covered with circular plates containing four openings to hold shells in the proper vertical

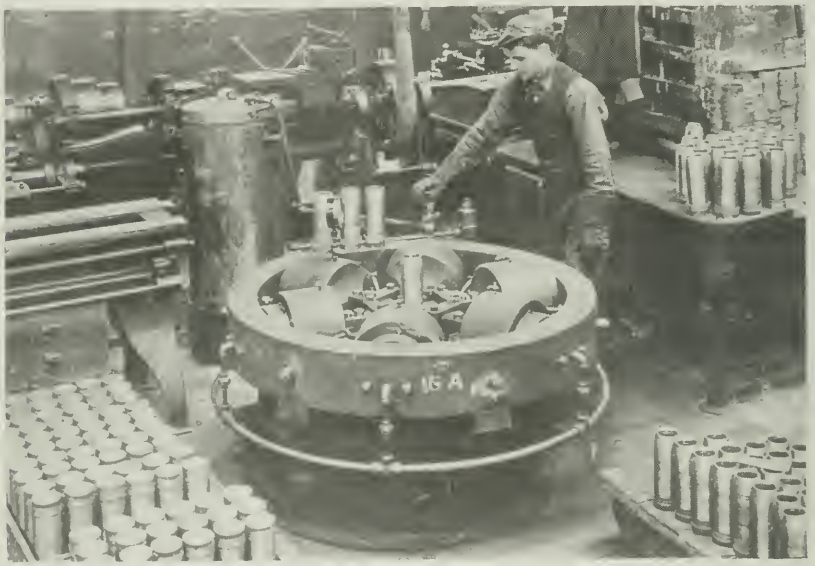


Fig. 6. Canadian Fairbanks-Morse Branding Press

position. The plates are connected to vertical spindles provided with four arms at the top so that, as a hot shell is removed and replaced by a cold one, the disc plate can be rotated a quarter turn to bring a fresh hot shell into position for the press man. The shells after nosing are allowed to cool slowly.

The final operation on the base of the shell consists of cleaning and polishing on a rag wheel to remove all signs of the heating operations. The machining of the nose constitutes another series of operations, the first of which is the rough turning of the outside. This is accomplished by means of a plate carrying a cam slot and attached rigidly to the bed of the machine. This slot effectively guides the cam roller which is rigidly connected to the lathe cross

slide and thus restricts the motion of the tool so as to give the correct contour to the shell nose.

The roller is held securely to the guiding face by weights and the feed of the tool is regulated by stops, a solid plate gauge being used to test for size over all. The nose is bored in the same way after grinding with an ordinary diamond point tool held in a short stout boring bar. The lathe carriage is guided in a cross-wise direction by means of a cam attached to the rear of the lathe bed as before.

The finish facing and tapping are done by turret lathes, a solid tap being used which is backed out by reversing the lathe spindle. The shells are now ready for grinding for which three Norton grinders are used The finishing of the shells by grinding is considered a success in every way by the management of this plant and they have deviated but little in their methods from standard practice.

The shells are centred by chucking at the rear end and by means

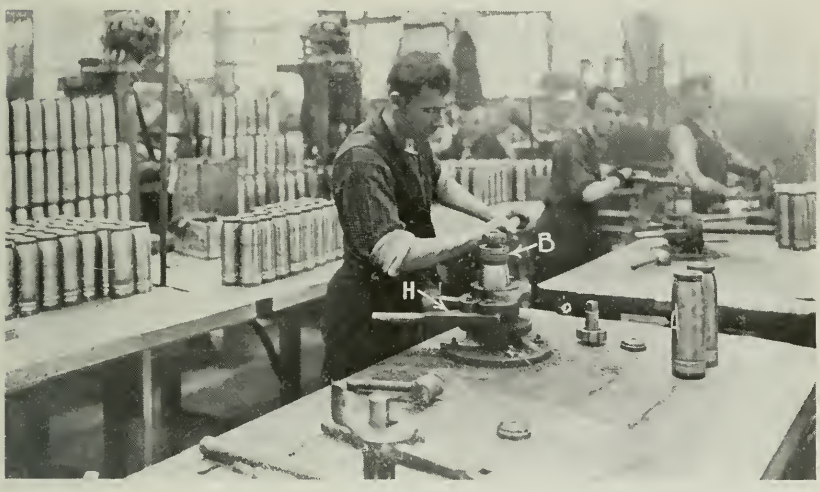


Fig. 7. Shell Vise and Ball-bearing Plug for Screwing Down Socket

of a plug carrying the centre at the front end. The machine is traversed in the usual way in grinding the cylindrical part of the work and a formed wheel is used only to finish the profile of the nose. Two plain grinders and one formed wheel grinder handle the output of the plant. The diamond problem is overcome by avoiding, as much as possible, wide formed wheels and the men in charge express themselves as well satisfied with the results. Following the grinding, the inside of the nose is turned to size and the shells receive their preliminary shop inspection in which particular attention is given to the undercutting and waving in the groove for the band. After this the shells receive their first government inspection which follows somewhat similar lines to the shop inspection.

Banding Operations

The work in connection with the copper rotating band consists of a series of operations. The marking is done at this point upon a Holden-Morgan marking machine and the bands are crimped in place by means of a hand lever press which sets it down into the groove at four points in the circumference. The banding press is of the hydraulic six-cylinder type, built by the Canadian Fairbanks-Morse Co. So successful has this press been that the company has undertaken its manufacture, and has sold a considerable number to other people engaged in the shell business. The machine is operated by a belt-driven pump, and has a number of interesting features. The shell is placed, open end uppermost upon a small plate at the centre with the pistons working radially towards it, and the band is pressed home in two operations between which the shell is given an eighth of a turn so that the entire circumference is affected.

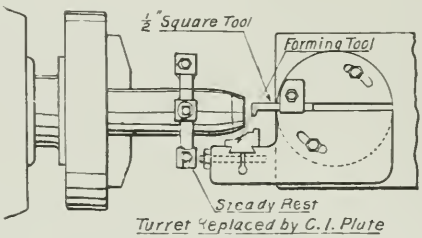


Fig. 8. Fox Turret Lathe with Turret Replaced by Set-up for Finishing Sockets

The press is quick acting and the entire operation requires less than one minute.

The turning of the band is done on small lathes using flat formed tools. The main tool is situated on the carriage in the usual place, while a smaller tool located in the centre of the carriage, so as to operate on the bottom of the work when the cross feed is reversed, is used to turn the flat parts of the band. A brass plate which acts as a rest for a hand tool is now slipped over the main forming tool and all burrs and ragged edges are removed from the turned band in this way.

Assembly

The case of the shrapnel may now be considered finished and only requires assembling with the interior parts. These consist of the tin powder cup, the diaphragm, a brass tube leading down through the centre and which screws into the diaphragm, the bullets and rosin matrix, the cap and plug, and several bits of muslin solder, etc. The first operation consists of placing the tin powder cup beneath the steel diaphragm which was placed in the shell previous to the nosing operation. The tubes are now screwed in place and a felt plug upon the end of a wire is inserted to prevent all particles of material or foreign matter from entering the tube or the powder

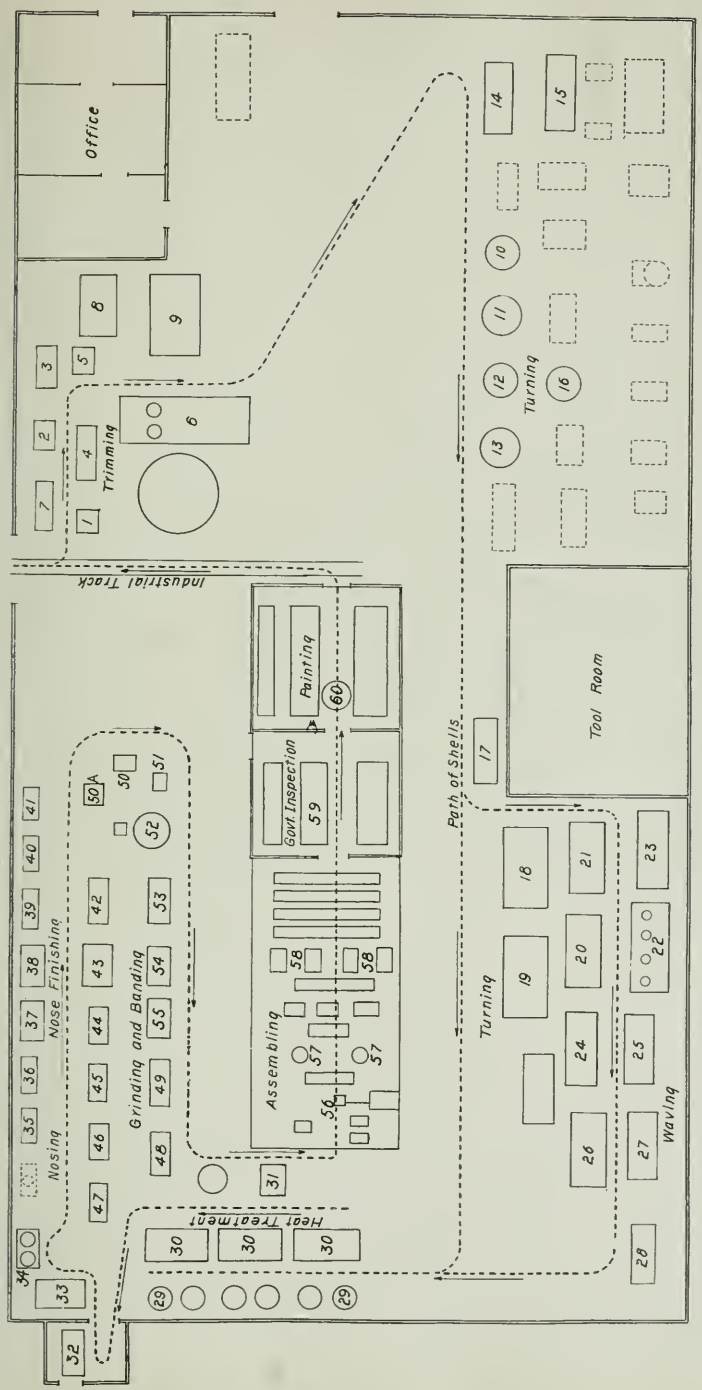


Fig. 9. General Layout of Plant Illustrating Path of Product and a Most Efficient System

SEE NEXT PAGE

case. This stopper remains in place until the completion of the assembly.

The bullets are stocked above on the gallery of the shop and come down to a filling trough by gravity through a tube in the same way that the diaphragm discs come down to the nosing press. This saves a considerable amount of floor space at points in the plant which are of necessity very much congested. The spout delivers to a trough at the end of which is a filling device especially designed to deliver the bullets to the shell in a steady stream rather than in a mass. It has been the experience of the officials of this plant that this is a most important point as the space cannot be perfectly filled by the bullets if these be dumped in bodily.

To insure the bullets being thoroughly packed, the shell rests

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GENERAL LAYOUT OF PLANT ILLUSTRATING PATH OF PRODUCT AND A MOST EFFICIENT SYSTEM

Trimming

1—Pipe machine.
2—Rogers bolt cutter.
3—Bertram lathe.
4—Niles lathe.
5—Hall bolt cutter.
6—Ingersoll miller.
7—Bertram lathe.
8—Ingersoll miller.
9—Double spindle boring machine.

Boring

14—Horizontal boring mill.
15—Horizontal boring mill.
21—Conradson turret.
22—Foote-Burt 4-spindle drill.

Waving

24—American lathe.
25—Bertram lathe.
26—American lathe.
27—Bertram lathe.

Turning

10—Bullard mill.
11—Bertram mill.
12—Bullard mill.
13—Bertram mill.
16—Bertram mill.
17—American turret.
18—Steinle turret.
19—Steinle turret.
20—Pratt & Whitney turret.
23—Gisholt lathe.
28—Small lathe—turn for nosing.

Heat Treatment

29—Six Fairbanks-Morse oil furnaces.
30—Three oil tanks.
31—Scleroscope.
32—Fairbanks-Morse sand blast machine.
33—Nosing press.
34—Fairbanks-Morse furnace.

Finish Nose

35—Lathe, tap and face.
36—Lathe, tap and face.
45—Lathe, tap.
46—Lathe, turn profile.
47—Lathe, turn profile.
48—Lathe, turn profile.

Grinding

37—Norton grinder—grind body.
38—Norton grinder—grind body.
43—Norton grinder—grind body.
44—Norton grinder—grind profile.
39—Lathe, bore nose profile.
40—Lathe, bore nose profile.
41—Lathe, file profile when necessary.
50—Marking machine.
50A—Washing machine.

Banding

51—F.-M. hand press—set band.
52—Fairbanks-Morse banding press.
53—Small lathe—turn band.
54—Small lathe—turn band.
55—Small lathe—turn band.
49—Small lathe—turn band.

Assembling

56—Bullet spout.
57—Rosin pots.
58—Four Fox-turret lathes, turn socket.
59—Inspection benches.
60—Fairbanks-Morse painting machine.

during the process upon a vibrator plate which vibrator is very similar to that used on matched plate moulding machines. Short, rapid motion has been found to give better results than a longer and slower motion. The correct number of bullets is ascertained by weighing after which the shells go to the rosin pots. The bullets are not heated as is done in many plants, this being considered unnecessary if due care be exercised in the pouring of the rosin and in maintaining it at the proper temperature. Experience and the making of sections of a number of finished shells have amply borne out this practice in a very satisfactory manner.

After filling, the shells are again corrected for weight and are ready for screwing in the sockets. For this purpose, the case is firmly held in an upright position by a special vise operated by a lever and cam. The threads and seating parts of the socket are first luted with shellac and then screwed home by means of a special ball-

Fig. 10. Painting, Final Inspection and Crating

bearing driver and a large, single-ended tap wrench. The plug used for this purpose is a very simple and efficient affair. It consists of the squared shank and a straight, threaded portion of the same diameter and pitch as the inside threaded part of the sockets. Upon the upper part of the thread are two hardened steel nuts fitted with grooves on their adjacent sides to form the raceway for a ball bearing B. The bottom nut seats against the socket to be screwed in and is jammed by the upper nut on account of the much greater friction in the thread bearing than in the ball bearing. For the same reason, the backing of the wrench instantly releases the plug from the socket from which it can be unscrewed by hand.

The tube is soldered to the socket by means of a special copper formed in the shape of a ring of the right size and provided with a groove on one side to allow the escape of air. The solder is

used in the form of wire which is first coiled and then cut into rings, no acid being permitted in the process.

Finishing the outside of the socket in conformity with the general contour of the shell nose is done on four small lathes equipped with formed tools and steady rests. These lathes remove all surplus solder and in doing this perform the last manufacturing operation upon the shells. The latter now receive their final shop inspection and are passed on to the officials of the government for their final

Fig. 11. Shipping and Receiving Department—Loaded Industrial Motor Car.

gauging and inspection. Upon their being passed and the receipt of favorable report from the firing test, the shells are painted to prevent deterioration by weather conditions.

Tests

It will be remembered that, at the preliminary inspection, two were chosen from each series of 120, one of which was to be prepared and sent to the arsenal for the firing proof and, from the other, a section is to be cut out as designated by the inspector for the preparation of a specimen for the tensile test of the steel. The shells are painted on a very ingenious machine designed and built by the Canadian Fairbanks-Morse Co. This machine, like the banding

press, is being constructed in numbers and sold to other shell manufacturers. It contains six vertical spindles spaced evenly about a flat circular table. These spindles are kept in constant rotation at a speed of about 250 r.p.m., by a motor at the base and which receives its current through a lamp socket from the ceiling. The shells are placed in an inverted position upon the upper ends of the spindles, the friction being amply sufficient to drive them with the necessary force. The painting is done with a flat pad from paint receptacles conveniently attached to the machine. The table revolves upon ball bearings and the whole is on wheels so that it can be readily moved to the work. The time required for the painting is one minute per shell for the three coats as specified by the government.

The shells are removed from the machine with a special holder that grips them by the copper band and are placed in racks to dry. After the painting is completed, the shells are finally inspected and packed in wooden cases holding six each. These are loaded upon an industrial railway car and taken to the shipping department whence after inspection of the cases, they are loaded into railway cars two tiers high and start upon their long journey to France, and after loading with the powder charge and primer, to the battle fields.

System a Factor

The most striking point in connection with this plant is the evident perfection of the system employed. From the moment the forgings reach the plant, not a backward movement is made. The flow of shells through the plant is smooth and uninterrupted and at no point do the streams cross over. The result of this is evident. Foremen and superintendents are conspicuous by their absence in the shop and are to be found in the office attending to business.

The transfer truck and pyramid system is used almost entirely and the shells are unloaded upon the floor only where absolutely necessary. Another striking feature is the utilization of all the machinery of the plant, both great and small, the devices to this end being in many cases original.

The company has bought little, if any, outside machinery. On the contrary, the special machines required have been designed and built within the plant and many have been sold to outsiders. The co-operation of Canadian manufacturers in assisting each other in this and in other ways has not only been the surprise of the business to foreign companies, but has been, perhaps, the greatest factor in the successful handling of this great work by Canadian financiers and manufacturers.

A SOUTHERN BRITISH COLUMBIA POWER SYSTEM

By Vincent S. Goodeve, '10

Many people in the Eastern provinces of our Dominion are inclined to regard British Columbia as a comparatively new and undeveloped province. Yet, as far back as 1897 gold and copper mining and smelting had reached such a stage as to cause far-seeing men to begin the construction of a hydraulic power plant to supply the promised market. I refer to the West Kootenay Power & Light Co., from whose system nearly all of the mining and smelting industries of what is known as the Kootenay and Boundary countries, are supplied with power. Much of the ore in these districts is of such low grade as to require a good supply of cheap power in order that the ore may be handled in sufficient quantities to render its mining and smelting profitable.

In 1908 the company were supplying power from their first plant situated at Lower Bonnington Falls on the Kootenay River about ten miles from Nelson. The available load at that time was 1,000 h.p. at the end of a 32 mile transmission line. That the venture of the company was justified is evidenced by the fact that this original plant of 4,000 h.p. capacity is now used as a stand-by while their second plant at Upper Bonnington Falls, about one mile from the first and of 16,000 h.p. capacity, together with No. 3 plant at Cascade City on the Kettle River and of 3,900 h.p. capacity, are required to supply the present load. No. 2 plant was completed in 1907, and in the same year the company took over the system of the Cascade Water, Power and Light Co., including what is now the No. 3 plant, which was supplying power in the Boundary country but which had not the capacity to supply the increasing demand. Forthwith, the Bonnington power was extended into this country and arrangements made whereby either source may be utilised to supply a limited supply of power to the other system in the event of a breakdown or shutdown for any cause.

The transmission voltages and places supplied from the various plants are as follows:—

No. 1 plant—Dead, and its customers supplied by special transformer in No. 2 plant, transmitted at 22,000 volts to Rossland, Trail and Silver King Mine.

No. 2 plant—60,000 volts supplied to Rossland, Grand Forks, Phoenix, and Greenwood.

No. 3 plant—22,000 volts, supplied to Grand Forks, Phoenix, Greenwood and Boundary Falls.

All current is transmitted at 60 cycles and stepped down to the prevailing distribution voltage, usually 2,200 volts, at the various substations.

Someone has rightly said that if the province of British Columbia were flattened out it would have twice its present area. The building of a transmission line in such a country is not an easy task. The power must go wherever the mines and smelters are located. The smelters must be built wherever the character of the

land and the railroad facilities will permit. These conditions lead the power lines over rough land to altitudes of six thousand feet and down again to two thousand feet. The patroling and repairing of such a line is an expensive matter, and the company found it better to build a line requiring very little attention but costing more than the flimsier line. The 60,000 volt line is a model in this respect and its 84 miles of duplex three phase line give remarkably little trouble. It is also remarkably straight considering the character of the country through which it passes. The heavy cedar poles are spaced only from 100 to 150 feet apart. The cross arms are heavy and the butts are often placed in blasted holes in solid rock. Only a few freak poles have shown signs of decay as yet, and only once or twice has the lightning been known to set fire to the pole or crossarm. The line is not sectionalised. One line can carry all the load, so that as soon as trouble is found to be on either line, the entire load is thrown on the good line. Being on separate poles, trouble on one line does not cripple the other. So amply has the system been designed that it has not been found necessary to transmit at the rated voltage as yet, but current is transmitted at 40,000 volts by using taps in the windings of the transformers at the generating and receiving stations. This causes a saving in the expenses of locating and replacing broken down insulators for even the most up-to-date systems have breakdowns now and then from flaws in apparently good porcelain and stresses due to internal surges. The cables are arranged in an equilateral triangle by placing one cable at the top of the pole. The other two are on the crossarm. This formation is desirable to equalize the mutual induction of each wire on its mates and to facilitate transposition.

All the buildings and equipment of the system were designed to last and to accommodate large additional capacity. The available power at Upper Bonnington Falls is only partly developed even with the addition of another 8,000 h.p. unit, which is being installed at present. This last addition will be required to supply power for the electrification of the C.P.R. from Castlegar to Rossland. The substations are all built along the same plans. Separate rooms are provided for each bank of transformers, the high tension switching equipment, and the switchboard and operating room. No provision is made for elaborate systems of relays to disconnect lines when the voltage drops or the current is interrupted. The simple inverse-time-limit overload relays afford sufficient protection on both the high tension and feeder switches.

The accompanying illustrations of power house No. 2 give some idea of the difficulty with which it was erected. 70,000 cubic yards of solid granite had to be excavated for the forebay, powerhouse site and tail race. The building is of reinforced concrete and is not at all ugly or out of keeping with the natural beauty of its surroundings. The interior is roomy and provision is made in the present building for four units of 8,000 h.p. capacity each. Two of these are installed and in operation and a third is now being installed as mentioned before.

In this article I have endeavored to omit the quoting of capacity

data and similar information as I have always found that it makes wearisome reading. Instead of detailing the equipment of the powerhouses and substations, which is pretty much standard and is familiar to most students interested in power plant construction, I have outlined some of the conditions under which this system was constructed and is now operated. Every little system has troubles all its own and it is these peculiarities which make the descriptions of plants and systems interesting.

THE MECHANICAL AND ELECTRICAL CLUB OF THE ENGINEERING SOCIETY

1. Name of Club.

The name of the Club shall be, "The Mechanical and Electrical Club of the Engineering Society." (The relation of this club to the Engineering Society is provided for in the revised constitution of the Engineering Society, adopted.

2. Membership.

(a) The membership of the Club shall be open to all students in Electrical and Mechanical Engineering in the Faculty of Applied Science and Engineering, University of Toronto. Such members do not require nomination or election.

(b) Others desiring to become members shall be elected by the Club. Such candidates shall be nominated at a regular meeting, the voting on this nomination to take place at the following regular meeting.

3. Divisions of Club.

The Club shall be divided into two sections, namely:

(a) A Senior Section consisting of members of the third and fourth years in Electrical and Mechanical Engineering.

(b) A Junior Section consisting of members of the first and second years in Electrical and Mechanical Engineering.

4. Officers.

(a) The officers shall consist of a chairman, a vice chairman, a third year councillor, a second year councillor, and a first year councillor.

(b) The chairman shall be a member of the fourth year and hold office on the Executive of the Engineering Society as provided in the Constitution of the Engineering Society.

(c) The vice chairmen shall also be a member of the fourth year.

5. Duties of Officers.

(a) It shall be the duty of the chairman to preside at all general meetings, call meetings for the election of an executive or for the transaction of any other business pertaining to the interests of the club. He shall enforce due observance of the constitution and by-laws, shall make no motion or amendment nor vote on any

question or motion unless the club be equally divided when he shall give the deciding vote.

(b) The vice-chairman shall perform the duties of the chairman in the absence of that officer. He shall also preside at the meetings of the senior section, provide places for these meetings and arrange for topics of discussion. He shall also collect fees from the members of the fourth year.

(c) The third year councillor shall act as secretary to the club and also collect fees from the members of the third year. He shall keep a record of the proceedings of the club at the general and executive meetings. He shall also make mention in the minute book of the meetings of the two sections.

(d) The second year councillor shall act as treasurer, collect fees from the members of the second year and keep an account of all expenditures and receipts in an account and cash book. He shall also arrange the meetings of the Junior section and preside at such meetings.

(e) The first year councillor shall act as curator and shall also collect the fees from the members of the first year.

6. Election of Officers.

(a) The Chairman shall be elected at the annual elections of the Engineering Society.

(b) The vice-chairman, third year councillor and second year councillor shall be nominated at the last general meeting of the club, the elections to take place one week later.

(c) The first year councillor shall be nominated at the first general meeting of the fall term, elections to take place one week later.

7. Duties of Members.

(a) Members are requested to read papers before the club at the general meetings.

(b) It is the duty of all members to take part in any discussion.

(c) Papers presented shall become the property of the club.

8. Meetings.

(a) The general meetings shall be held once a month, alternately with the general meetings of the Engineering Society, such dates to be chosen by the executive of the Engineering Society. Meetings to commence at 4 p.m.

(b) The senior section shall hold their meetings on the first Thursday of the month at 8 p.m.

(c) The Junior section shall hold their meetings on the fourth Thursday of each month at 8 p.m.

(d) It is also recommended that these meetings be not addressed by an outside speaker, but that they take the form of open discussion in which everyone should take part. However, this is left to the discretion of the vice-chairman and second year councillor who are at liberty to form their own rules and regulations, provided that said rules and regulations meet with the favor of the executive of the Engineering Society.

9. Fees.

(a) The annual fee shall be twenty-five cents to members of the Junior and Senior sections.

(b) All fees shall be paid within the first academic month.

10. Alterations to Constitution.

Notice of motion regarding proposed alterations to the constitution shall be given at the previous meeting and a written notice of motion shall be handed to the secretary, voting to take place at the next general meeting.

By-Laws Relating to General Meetings

1. Rules of Order.

(a) The order of business shall be as follows: Opening, reading of minutes, nomination of members, reading of communications, reports of committees, election of members, unfinished business, new business, programme and closing.

(b) The chairman, or in his absence, the vice chairman, shall conduct the meeting, or in the absence of such officers a chairman pro tem shall be chosen by the club.

(c) The chairman shall be privileged to debate on all subjects upon calling any member to the chair.

(d) The minutes shall not be amended except to correct error in fact.

(e) Any member who wishes to speak shall rise and respectfully address the presiding officer. He shall confine himself to the question under discussion and avoid personalities.

(f) If two or more members rise to speak at the same time the presiding officer shall decide who shall speak first.

(g) A motion must be moved, seconded and repeated aloud from the chair before it is open for debate.

(h) Motions must be written out and handed to the secretary, signed by the mover and seconder.

(i) When a member is called to order he shall resume his seat until the point of order is decided.

(j) An appeal may be made at all times from the decision of the chair. The presiding officer shall put the question, "Shall the decision of the chair stand as the opinion of the meeting." Two-thirds vote of meeting is necessary to sustain the appeal.

2. Alterations to By-Laws.

The same procedure shall be adopted as is provided for in changing the constitution.

UNKNOWN ADDRESSES

The following is a list of graduates, regarding whose addresses we have not reliable information. Our readers will confer a favor if they will kindly advise us of the correct addresses of any of the men listed below:—

Abendana, E. M., '14; Alexander, J. H., '04; Allen, F. G., '07; Armour, R. H., '05; Bertram, G. M., '01; Binns, R. E., '13; Blair,

W. J., '02; Bowman, A. M., '86; Brackenreid, T. W., '11; Brown, D. B., '88; Brown, H., '11; Browne, E. W., '09; Bruce, W. J., '07 Campbell, A. W., '06; Campbell, R. J., '95; Campbell, A. M., '04; Campbell, A. J., '04; Cameron, M. G., '09; Carey, B., '99; Chambers, E. V., '14; Chantrell, E., '05; Charlebois, J. P. C., '08; Chisholm, D. C., '10; Christie, F., '06; Clark, J., '00; Coulter, G. P., '07; Darrich, J., '08; De Guerre, F. C., '11; Derham, W. P., '09; Dowling, F., '05; Elliott, J. C., '99; Evans, J. H., '11; Evans, S. D., '07; Foreman, W. E., '99; Forester, C., '93; George, R. E., '03; Gourlay, W. A., '03; Heebner, M. B., '11; Horton, J. A., '03; Hull, H. S., '95; Hunter, A. N., '08; Irwin, W. J., '10; Kay, E. W., '07; Kean, D. J., '09; Keefer, A. H. E., '09; Keys, W. R., '08; Lott, A. E., '87; Macdonald, F. R., '08; Macdonald, J. A., '10; Macdonald, J. B., '10; Macdougall, A. C., '01; McKay, A. G., '07; MacKay, J. T., '02; McKenzie, D. W., '05; McLellan, R. A., '11; McLeod, G., '09; McPherson, J., '06; McTaggart, A. L., '94; Malone, J. E., '08; Martin, F., '87; Matheson, W. C., '01; Maus, C. A., '03; Mennie, R. S., '02; Milligan, F. S., '10; Mitchell, L. C., '11; Montague, F. F., '06; Moore, F. A., '03; Munro, F. V., '03; Murray, J. D., '07; Niebel, E. H., '11; O'Brien, E. D., '05; O'Gorman, C. A., '09; Pae, A. W., '09; Parke, J., '04; Paton, T. K., '07; Paulin, F. W., '07; Pearson, C. L., '11; Pope, A. S. H., '99; Proctor, A. I., '09; Robertson, D. F., '03; Roaf, H. R., '00; Sanders, W. K., '06; Scott, W. A., '06; Shipley, A. E., '98; Smiley, R. W., '97; Smith, J. H., '03; Stamford, W. L., '08; Stevenson, W. H., '01; Taylor, W. V., '93; Thomas, V. C., '08; Wright, R. T., '94; Wilson, W. H., '10; Whelihan, J. A., '03; Villeneuve, T. L., '08.

INFORMATION RE CORRESPONDENCE FOR PRISONERS OF WAR IN GERMANY

1. Letters (letters should be left open) postcards and postal parcels should be addressed as follows:—

1. Rank, initials, name.
2. Regiment, or other unit.
3. British (or Canadian, French, Belgian or Russian) prisoner of war.
4. Place of internment.
5. Germany.

Place of internment should be stated always, if possible, and parcels cannot be accepted unless place of internment is stated. All addresses must be in ink.

2. Communications should be limited to private and family news and to necessary business communications, and should not be sent too frequently.

No references to the naval, military or political situation or to naval or military movements and organizations are allowed. Letters or postcards containing such references will not be delivered.

3. Friends of prisoners of war are advised to send postcards

in preference to letters as postcards are less likely to be delayed. If letters are sent, they should not exceed in length two sides of a sheet of note paper and should contain nothing but the sheet of note paper. On no account should the writing be crossed.

4. Letters cannot for the present be accepted for registration.

5. Postage need not be paid either on letters or parcels addressed to prisoners of war.

6. No letters should be enclosed in parcels, and newspapers must not on any account be sent. So far as is known there is no restriction on the contents of parcels; tobacco may be sent and will be admitted duty free but food stuffs of a perishable character should not be sent. Parcels should not exceed 11 pounds in weight.

7. Remittances can be made by money order to prisoners of war. Instructions as to how to proceed can be obtained from postmasters of Accounting Post Offices. The transmission of coin, either in letters or parcels, is expressly prohibited. Postal notes and bank notes should not be sent.

8. It must be understood that no guarantee of the delivery of either parcels or letters can be given and that the Post Office accepts no responsibility. In any case, considerable delay may take place and failure to receive an acknowledgement should not necessarily be taken as an indication that letters and parcels sent have not been delivered.

9. So far as is known, prisoners of war in Germany are allowed to write letters or postcards from time to time; but they may not always have facilities for doing so and the fact that no communication is received from them need not give rise to anxiety.

REUNION OF MONTREAL TOIKE OIKES

On the evening of May 7th a most enjoyable little reunion of about two dozen Montreal "School" men was held at the University Club, Montreal. Mr. Walter J. Francis occupied the chair and Dean Ellis the place of honor. At the conclusion of the dinner Dean Ellis proposed the toast to the "Toike Oikes at the Front" and reviewed some of the history of the School that was new to most present. Following the Dean, Mr. Ross expressed some felicitations while Mr. H. W. Fairlie, B.A.Sc., '10, who had just returned after a year's residence in Winnipeg, also spoke.

The annual elections were then held, and Mr. J. M. R. Fairbairn, '93, assistant chief engineer of the C. P. Ry., was elected president; Mr. W. D. Black, B.A.Sc., '09, vice-president, and Mr. W. H. Sutherland, B.A.Sc., '02, secretary-treasurer; while the old Advisory Committee of Messrs. J. M. Robertson, '93, D. C. Tennant, B.A.Sc., '09, L. R. Wilson, B.A.,Sc. '09, and C. W. B. Richardson, B.A.Sc., '07, was re-elected.

FAREWELL DINNER TO MEMBERS OF CLASS 1913

On the evening of May 7th the members of year 1913, residing in Toronto, held a farewell dinner at the Walker House for their

members who are leaving with the Second Canadian Expeditionary Force. Messrs. Chas. Avery and N. F. Parkinson of the 15th Battery C.F.A., were present, and the year greatly regretted the inability of the others to be with them. Mr. E. R. Gray, president of the class, was the toastmaster. After each member had had an opportunity to make a speech or tell a story, a business meeting was held at which it was decided to form a Toronto Branch of the class.

The following were elected as officers:—John S. Galbraith as president; and R. L. Hearn, of 249 Dovercourt Road, Toronto, as secretary. Each member of the year is asked to keep in as close touch as possible with these officers.

The men of this year who have already left on active service are:—First Contingent, A. J. Gray, C. A. Bell, C. B. Ferris, E. S. Foulds, L. C. M. Baldwin, A. G. Gray, F. S. Rutherford.

Second Contingent—J. McV. Strathy, F. F. Howlett, C. R. Avery, C. E. Kilmer, N. F. Parkinson, H. Webster, and B. H. Segre.

C.O.T.C. CAMP

The Universities' Officers Training Corps camp which was held from May 3rd to May 15th, may be set down as a success in every way. Conceived as a preparation for self defence and carried out with the esprit de corps of college men, turned soldiers, all can agree with Colonel Lang when he expressed complete satisfaction with the results obtained.

The course of instruction was progressive in character. At first the men were put through the rudimentary exercises of squad drill. This was further developed until at the close of the camp the corps worked as a battalion. Practical examinations for those who had qualified on the written examinations, were also held.

For those who were not at camp an idea of the day's tribulations from the standpoint of a private may be of interest, and the fact that Professors Gillespie and L. B. Stewart were also privates in the strictest sense of the word is worthy of note.

Sometime in the middle of the night a bugle "goes" off and you find it is 5.45 a.m., and roll over only to be shortly awakened by the band playing some insane combination of futurist harmonies as it passes right through the lines. You have a few minutes' meditation and then the small fry get their innings. Sergeants and other non-coms. rush up and down the lines, "Double up men! Roll call. Always move at the double." Roll call and a short run are followed by the morning's ablutions and breakfast at 6.45 a.m. After cleaning the tents and taking physical exercise, everybody drills until noon. From 2 p.m. to 4.30 drill is continued and then everybody is off for the day.

The camp was inspected by Gen. Lessard on May 13th and again the same afternoon H.R.H. the Duke of Connaught critically inspected the corps. On Friday a field day was held followed by a march past before Gen. Hughes. This completed the

work of the camp and on May 15th it was a bronzed lot of men that marched gaily up University Ave. to be dismissed until individually called on to serve their country by the call of duty.

ON ACTIVE SERVICE

The following "School" men have enlisted with the Second Canadian Contingent, in addition to those previously mentioned in APPLIED SCIENCE:—

J. L. R. Parsons, '01; E. R. Birchard, '09, with Eaton Battery.

E. G. MacKay, '10, with 91st of Hamilton.

A. L. Steele, '10, with Canadian Engineers at Ottawa.

E. F. Chesnut, '11, with No. 1 Co. 19th Battalion.

L. E. Jones, '11; A. M. Mackenzie, '14; G. H. Hally, '14, with 26th Battery at Kingston.

A. G. Scott, '15, with 42nd Regiment at Petawawa.

J. A. Tom, '15; I. M. Macdonell, '15; H. K. Wyman, '15; C. N. Geale, '15, and G. A. Gooderham, '15, with Aviation Corps at the Island.

C. C. Anderson, '16, R. Tyrwhitt, '16, with Stationary Hospital, C.E.F.

A. H. Macfarlane, '16; A. M. Thomas, 16, with No. 2 Co., 35th Battalion.

C. H. Wheelock, '16, with Machine Gun Det., 35th Battalion.

P. A. Durbrow, '17, with 8th Bde., C.F.A.

W. A. Bishop, '17; V. E. Ives, '17; F. R. Allan, '18; Machine Gun Det., 35th Battalion.

L. J. Deacon, '18, with 7th Bde., 26th Art.

H. W. Orr, '18, with 26th Battery, 7th Bde.

C. E. Kilmer, '13.

To date we have record of 69 "School" men with the First Contingent and 127 with the Second Contingent, exclusive of those enlisting with the Second University Overseas Company.

SCHOOL MEN ON THE CASUALTY LIST

Jeff Taylor, '08, has just been reported killed.

Lieut. E. A. Greene, B.A.Sc., '11, of 9th Battery, is reported missing.

Capt. D. H. C. Mason, B.A.Sc., '07, of 1st Brigade, 3rd Battalion, is reported missing.

Sergeant C. A. Bell, '13, of 3rd Brigade, 2nd Fd. Co'y is reported missing.

Pte. A. G. Code, B.A.Sc., '10, of Canadian Army Service Corps, reported seriously wounded.

Capt. R. Y. Cory, B.A.Sc., '08, Canadian Army Service Corps, 15th Battalion, reported prisoner.

Lieut. H. F. H. Hertzberg, '07, of 2nd Field Co., Canadian Engineers, has been wounded.

Lieut. G. E. D. Greene, B.A.Sc., '09, of 3rd Battalion, is reported prisoner.

Lieut. Herbert N. Klotz, '09, killed while fighting around Ypres.

One of the School men to receive recognition from the Imperial Government is M. B. Watson, 1910, who went over to England with the First Canadian Overseas Expeditionary Force. Shortly after his arrival at Salisbury he received a commission as 2nd lieutenant in the Royal Engineers, and is at present doing instruction work at Buxton, England.

While attending the School, Mr. Watson was connected with the 2nd Field Company, Canadian Engineers, receiving his corporal's

stripes. On the outbreak of war he enlisted with his old company and trained with them at Valcartier, where he was, for part of the time, in charge of the local telephone system.

The accompanying photograph shows Lieut. Watson standing on the end of a barrel raft which was built under his instruction in 20½ minutes. Since leaving Toronto he has gained 20 pounds, and as may be seen from the photograph, has cultivated a very creditable eyebrow on his upper lip.

Editorial

UNIVERSITIES' OVERSEAS COMPANY

Following the suggestion of Capts. MacDonald and Molson, of McGill University to Hamilton Gault, that reinforcements for the Princess Patricia's Canadian Light Infantry be recruited from the C.O.T.C., the first University Overseas Company was formed at Christmas at McGill. It has been in training ever since with Capt. MacDonald in charge and Capt. Molson second in command. The subalterns being Capt. G. M. Smith, of Victoria College and Lt. D. G. Hagarty, '16. The first company is now in camp at Niagara and recruits are being called for the second company. It is hoped that the 110 men which Toronto is expected to contribute, may offer their services very shortly.

The company is not attached to any battalion and the work will not be wholly regular infantry drill but mutual instruction will be the strong point. As officers are very scarce in England it is the object of this company to qualify its men as officers so that they can obtain commissions when arriving in England. To date about 50 School men have enlisted and should any graduates be seriously considering going to the front no better opportunity could be offered them.

IRISH CHANNEL RAILWAY

In the November, 1913, issue of APPLIED SCIENCE appeared an article on the unifying of the British Empire by "A Railway Across the Irish Channel" proposed by H. G. Tyrrell, C.E., '86. This article at the time it was published was much discussed in British papers and magazines, and also in the British Parliament. The following extract from an article on this subject in Popular Science for October, 1913, sets out a few of the measures advocated by Mr. Tyrrell as precautions in case of war.

"The Irish Channel railway is of international interest and importance because it would form one link in the proposed Imperial Route connecting all parts of the British Empire. Over this route it is intended that travel should be conducted with the greatest possible speed, and in the event of war, Great Britain would have independent communication with all parts of the Empire and could receive supplies from Australia and New Zealand in about twenty-one days. Its course would lie across the Atlantic and Pacific oceans by way of Canada, instead of through the Suez Canal and the Mediterranean Sea, and past the ports of foreign countries. Food Supplies from Canada and the west would then arrive in Great Britain at ports on the west coast of Ireland, which in times of war, would be much safer than others further to the south or on the English Channel adjoining France."

The wisdom of this plan is now all too evident, though too late. However, when the war is over the northern Irish ports will doubtless be developed.

SIGNS OF THE TIMES

Great is the credit due Canada for weathering the difficulties of economic adjustment as she is. Money is accumulating rapidly and the change from the British to United States money market was effected without trouble. The chartered banks, which are the safety valve of Canada, are in an excellent position and extend credit when it is deserved. The agricultural prospects are good and trade is improving. Few mortgage payments, of either principal or interest, are in default. Manufacturers are cutting new trade channels, encouraging home demand, and increasing their exports. In short, everything indicates a period of prosperity for Canada.

MADE IN CANADA

We must not forget that it was upon German science that the trade of Germany was developed to such a marked degree. The very base of all their industries was science and particularly the science of chemistry. The standardizing of all products, the development of industries, the invention of new products, the utilization of by-products, etc., all depend on chemical research. It is, therefore, quite evident that for Canada to become a "Made in Canada" country the chemical engineer has a great future ahead of him and is bound to become more and more the power of commerce.

AVIATION

Toronto is one of the continent's busiest centres of aviation. But two weeks ago there was only one aeroplane around Toronto and now there are seven. In a few weeks Toronto has become the greatest flying centre on the continent, and it will not be long before the machines, motors and practically all equipment will be built here. Should the war establish the aeroplane industry on a firm footing in Toronto, the credit will be due to a few enterprising men, who have worked without any government help, such as other countries give. One of these men is J. A. D. McCurdy, '07, managing director of the Curtiss Aeroplane & Motors, Ltd., who is looking after the Curtiss-McCurdy flying school at Hanlan's Point. They have four machines that are used in the course of instruction. For the early training the flying boat and slow land machine are used, while for finishing the course in land flying a powerful tractor, making 85 miles per hour, is used. The final stages are performed in a 160 horsepower flying sea-plane. The school will accommodate a class of thirty at a time.

PERSONALS

School Men on Hudson Bay Railway—Le Pas Division—J. P. Gordon, '04, assistant chief engineer. Division No. 2, Goose Lake, Mile 137—A. L. McNaughton, '03, resident engineer. Division 3, Landing River, Mile 280—S. Hett, '06, resident engineer. Division 4, Landing River, Mile 280—J. W. Scott, '11, resident engineer.

John S. Galbraith, B.A.Sc., '13, has received a commission with the 10th Royal Grenadiers and is going into camp with them at the end of May.

E. E. Hugli, B.A.Sc., '14, is draughting for the Mond Nickel Co., Coniston, Ont.

C. N. Geale, B.A.Sc., '15, and **G. A. Gooderham,** B.A.Sc., '15, are in training with the Aviator Corps at the Island.

G. A. Colquhoun, '06, is estimating and designing engineer with the Hamilton Bridge Works. His address is 29 Sophia St., Hamilton.

T. G. Gravely, B.A.Sc., '11, is on shell inspection work with John Bertram & Sons, Ltd., Dundas, Ont. His address is Box 158, Dundas.

W. C. Blackwood, B.A.Sc., '06, has been appointed director of physics for the Central Technical Schools, Toronto.

W. A. Cowan, '04, formerly of the Intercolonial Railway, has been appointed to the staff of Mr. F. P. Brady, divisional engineer for the Transcontinental Railway at Cochrane, Ont.

A. P. Linton, B.A.Sc., '06, assistant chief engineer, Board of Highway Commissioners for Saskatchewan, last week addressed the Regina Engineering Society on the Construction of the Traffic Bridge at Saskatoon.

Mr. K. H. Smith, '11, has been appointed resident engineer for the Dominion water Power Branch at Halifax, N.S., to have charge of field investigations covering the water powers of the Province of Nova Scotia. The investigations are being carried on under a co-operative arrangement between the Nova Scotia Water Powers Commission and the Dominion Water Power Branch.

Readers of APPLIED SCIENCE will be glad to hear of the very interesting and unique water power exhibit which has been arranged by the engineers of the Dominion Water Power Branch in the Canadian Pavilion at the Panama-Pacific International Exposition. As this exhibit has been conceived and carried out entirely by "School" men, APPLIED SCIENCE is arranging for a special descriptive article which will appear in a forthcoming number.

The following "School" men have recently been appointed to the staff of the Dominion Water Power Branch, Department of the Interior:—

Harold Leach, '14; **George Woods,** '16; **J. T. Rose,** '15.

These men will all be attached to the staff of the Manitoba Hydrographic Survey, of which Mr. M. C. Hendry, '05, is chief engineer.

The Canadian Government has recently arranged to have a reconnaissance survey made of the water powers of the Yukon territory. This work will be carried on under the personal direction of R. G. Swan, B.A.Sc., '09, chief engineer of the British Columbia Hydrographic Survey.

NEW AMMUNITION COMPANY

The Montreal Ammunition Co., of which Mr. H. H. Vaughan is president and Mr. G. H. Duggan, '83, vice-president, is a newly organized concern that will manufacture brass cases for shrapnel and high explosive shells. Heretofore these cases have not been manufactured in Canada, but orders were filled in Detroit and other cities of the United States. The new company will use part

of the plant of the Dominion Bridge Co. for its work. Mr. Duggan is general manager of the latter company, while Mr. Vaughan resigned his position as chief mechanical engineer of the C.P.R. to devote his time to the new concern.

OBITUARY

The death of Mr. T. Harry Mace, '05, occurred last week. For some time he has been associated with the patent office of the Dominion Government at Ottawa, and prior to this had a consulting practice here in Toronto. The deceased was also a member of the 3rd Field Company of Canadian Engineers.

We wish to convey our sympathy to Mr. A. V. Trimble, '04, in the loss of his beloved wife, who died suddenly on Sunday, May 2, at 94 Glendale Avenue.

Lieut. Herbert N. Klotz, '09

Following closely upon a letter written from northern France to the effect that he never felt better in his life and was enjoying himself, came a message that shattered all hopes of a safe return. Lieut. Klotz was always an ardent military man, and while attending Harbord Collegiate, took an active interest in the cadet movement. After graduating from the "School" he was engaged as a chemist with the Gutta Percha & Rubber Company, and was with them until he received a commission with the Mississauga Horse, and enlisted with the First Contingent. He is survived by his father, Mr. E. W. Klotz, of 40 Sussex Avenue.

APPLIED SCIENCE EXAMINATION RESULTS, 1915

PROFESSIONAL DEGREES

Degree of Civil Engineer—

G. A. Bennett, B.A.Sc., '10 (C.E.); J. B. Challies, '04 (C.E.); E. A. Davison, B.A.Sc., '05 (C.E.); Angus Smith, '94 (C.E.); D. S. Stayner, B.A.Sc., '10 (C.E.).

Degree of Mining Engineer—

A. D. Campbell, B.A.Sc., '11 (M.E.); B. Neilly, B.A.Sc., '08 (M.E.).

Degree of Mechanical Engineer—

A. M. Campbell, B.A.Sc., '05 (M.E.).

Degree of Electrical Engineer—

C. E. Palmer, B.A.Sc., '11 (E.E.).

Degree of Master of Applied Science (M.A.Sc.)—

C. R. Avery, B.A.Sc., '13; N. F. Parkinson, B.A.Sc., '13; C. S. Robertson, B.A.Sc., '13; O. Rolfson, B.A.Sc., '07; G. E. Treloar, B.A.S.c, '14.

SCHOLARSHIPS

The Boiler Inspection and Insurance Co.'s scholarship for general proficiency in mechanical engineering for the third year is awarded to L. L. Youell.

STANDING GRANTED ON ACCOUNT OF ACTIVE SERVICE

The following candidates have been granted standing in their respective years on account of having enlisted for active service:

First Year—T. B. Jack.

Second Year—W. H. Aggett, W. B. Andrew, W. D. Armstrong, W. H. Bauer, W. A. Bishop, E. S. Byers, E. R. Dafoe, P. A. Durbrow, E. B. Dustan, C. Hewson, J. H. Legate, F. A. McKinley, A. F. Norris, C. H. Smith, J. Ward, J. F. Young.

Third Year—C. C. Anderson, T. E. Armstrong, S. K. Cheney, T. A. Daniels, C. W. Edmonds, W. F. Hadley, F. J. Matthews, A. R. Mendizabel, F. S. Merry, H. B. Norwich, V. R. Pfrimme, W. W. Ritchie, C. Smythe, H. Stewart, A. A. Swinnerton, A. M. Thomas, A. B. Whaley, C. H. Wheelock, J. S. Wilson,

Fourth Year—R. M. Arthur, H. J. Burden, W. G. French, R. D. Galbraith, M. S. Haas, I. M. Macdonell, K. D. McDonald, E. V. McKague, W. D. Powell, W. E. Raley, G. W. Rutter, A. G. Scott, W. G. Shier, R. B. Sinclair, J. A. Tom, J. N. Williams, H. K. Wyman, B. M. Morris.

The degree of B.A.Sc. was conferred upon the following at a special convocation held last February: F. D. Austin, N. H. Daniel, W. E. Lockhart, W. B. Redman, L. B. Tillson.

Candidates whose names are followed by brackets must pass supplemental examinations in the subjects indicated:—

First Year

Civil Engineering—

Honors—J. C. Angus, J. C. Aykroyd, J. M. Breen, H. R. Burton, W. L. Clairmont, C. P. Coatsworth, O. G. Darling, H. J. Elliott, H. W. J. Fairclough, J. A. Garvi, R. B. Gordon, H. Harrison, S. H. Johnston, F. T. Julian, J. A. Langford, N. G. McDonald, P. L. McGavin, L. McGee, R. Mitchell, J. R. Mitchener, T. H. Norval, G. M. Pearce, G. V. Rayner, J. Roosky, W. L. Sagar, M. Samuels, C. R. Scott, D. G. Scott, G. E. Steele, H. G. Thompson,

Pass—E. Birdsall, W. G. Brown, F. W. Campbell, F. D. Ellis (algebra), N. H. Kearns, G. K. MacKendrick, K. J. McEachern (trigonometry, anal. geom.), C. R. Maddock (algebra), W. J. Parker, S. H. Pepler (elem. chemistry), D. A. Robertson, F. W. Simpson, C. H. Stalker, A. K. Sweetman (alg., trig.), F. H. Taylor, C. C. Wimperly.

Mining Engineering—

Pass—N. Bowman, C. A. Richardson.

Mechanical Engineering—

Honors—F. J. Booz, M. G. Lymburner, P. F. McIntyre, S. A. McLennan, J. A. Simmers, M. L. V. Weir.

Pass—R. A. Connor (trig.), M. E. Dickenson (anal. geom., German), H. T. Gorrie (alg., trig.), H. J. McCreary (alg.), J. H. Peters (trig., anal. geom.), W. D. Robertson (elec. lab., trig.), W. J. Scott, (anal. geom.), P. E. Williams (alg.).

Architecture—

Honors—G. R. Gouinlock, T. J. Young.
Pass—W. A. Mollard.

Analytical and Applied Chemistry—

Honors—J. E. Fasken.
Pass—J. E. T. Musgrave (trig., anal. geom.), M. D. Schell (alg.).

Chemical Engineering—

Honors—J. A. Affleck, R. D. Affleck, J. H. Forman, G. E. Goble.
Pass—K. H. Chamberlain (elec. lab.).

Electrical Engineering—

Honors—C. K. Duff, K. S. Gemmel, J. P. McClelland, E. W. McLeod, W. H. Orr, G. R. Shephard, J. M. Souter, G. F. Tracy, H. S. Weldn, C. M. Willey.

Pass—W. D. Brown, G. F. Bryant (anal. geom.), J. W. Gardner (trig., anal. geom.), F. E. Johnston, K. D. Kayler (trig.), G. L. Macpherson, C. J. McNamara, J. H. McVean, T. W. Penhale (trig.), W. M. Smith (trig.), G. B. Wigle, F. A. Wood, W. G. Woonton (alg.).

Second Year

Civil Engineering—

Honors—A. E. Berry, R. S. C. Bothwell, G. A. H. Burn, F. C. Christie, R. A. Crysler, W. P. Dale, R. R. Hawkey, U. C. Holland, C. A. Hughes, W. H. Hunter, R. W. Hurlburt, R. E. Jones, J. R. McLean, R. C. Manning, H. A. Parr, C. L. Pool, W. D. Proctor, R. D. Ratz, G. E. Stephenson, C. E. Tilston, V. Topping, G. E. Waite, R. S. Warwick, L. E. Willmott, G. Wood, N. C. Wood.

Pass—O. V. Ball, H. F. Coon, E. H. Corman, F. C. Darch (mineral lab., hydrostat.), H. L. Dowling, J. A. Fraser, J. R. Gilley (Fr.), W. K. Greatrex, L. H. Ingersoll (optics), E. W. Johnston (calc.), W. J. Le Clair, G. A. McEwen, F. McGinn, F. L. Mitchell, E. L. Moorehouse, (Fr.), C. E. Newman (sph. trig., survey), H. R. Nicholson, J. E. O'Brien, W. J. Peace, G. P. Pearson, T. J. L. Ryan (survey), L. R. Shoebottom, G. H. Sohn (calc.), G. W. G. Stevenson (calc.), R. E. Taylor, A. P. Thomson, E. Thompson, G. A. Webb (Fr.), G. A. Whately.

Mining Engineering—

Honors—E. R. Gilley, G. Hanmer, H. L. McClelland, J. E. Sharman.

Pass—E. R. Howes (calc., inorg. chem.), H. D. Wallace (calc.).

Mechanical Engineering—

Honors—E. Bell, M. G. Henderson, J. D. Relyea, A. M. Snider, C. E. W. Tindale.

Pass—A. B. Harris, S. G. McCandish, (calc.), E. McIlhargey (theo. of mechan., bank. and fin.), A. W. Swan (hydrostat.), D. D. Vaughan (calc.).

Architecture—

Honors—E. W. Haldenby, A. S. Mathers, H. R. Watson.

Pass—J. Banigan (calc.), F. R. Gibson (ord. of arch.), C. C. Thompson.

Analytical and Applied Chemistry—

Honors—J. V. Dickson.

Pass—O. G. Lawson (phys. chem., bank. and fin.), G. G. MacDonald (elec.), E. J. Tyrrell.

Chemical Engineering—

Pass—A. G. Knight (calc., metall.).

Electrical Engineering—

Honors—R. A. Barbour, G. E. Booth, F. M. Bryans, C. E. Burton, J. C. Colleran, C. E. Harrop, R. D. Huestis, G. F. Hutcheson, W. J. Nichol, E. W. Smithson, O. W. Titus, A. A. Tufford, J. S. M. Wallace.

Pass—J. Ballinger (calc.), S. B. Bingham, (calc.), H. S. Brown (calc.), S. W. Bumstead, N. Burwash (calc.), R. T. Eyre, D. E. Ferrier, J. I. Gram (calc.), A. F. Hanly (calc., theo. of mech.), M. Johnston (calc., optics), L. Levesque, W. A. R. Offerhaus, H. Reed, H. A. Tuttle.

Third Year

Civil Engineering—

Honors—E. B. Allan, H. A. Babcock, L. F. Barnes, W. L. Dobbin, J. H. Eastwood, M. Gurofsky, O. Margison, W. B. Mitchell, C. H. Ney, J. E. Pringle, S. R. Ross, W. B. Scott, R. L. Seaborne, R. L. Sievewright.

Pass—B. W. Bemrose (survey), E. Crosby, R. S. Dale, L. F. Gaboury (astron. and geod.), D. B. Gardner (astron. and geod.), D. G. Hagarty, G. C. Hagedorn (astron. and geod., theo. of struct.), R. M. Hare (astron. and geod., hydraul.), L. W. Harren, (theo. of struc.), C. E. Hastings, K. D. Jackson, J. R. Kirby, R. W. Kirby, L. A. Lee (astron. and geod.), J. R. McColl, E. A. O'Collaghan, N. L. Powell (theo. of struc., calc.), H. C. Rose (astron. and geod., hydraul.), G. B. Snow, R. M. Speirs (astron. and geod., theo. of struct.), F. S. Storms, J. A. Sureda, J. E. Tremayne (least sq., theo. of struc.), R. C. Ward.

Mining Engineering—

Honors—B. A. McCrodan.

Pass—F. W. Norton.

Mechanical Engineering—

Honors—J. R. Chapman, R. W. Kirn, J. C. Newcombe, J. P. Russell, H. A. Washington, L. L. Youell.

Pass—H. E. Breuls (alt. curr.), J. N. Cunningham, J. L. Delisle (thermo., calc.), A. Fleming, R. A. Macdonald (thermo., mech. of machin.), J. M. Watson.

Architecture—

Honors—R. T. C. Hoidge.

Pass—L. Husband, W. S. Kidd, G. H. Schwartz, J. L. Skinner (theo. of struct.), A. F. R. W. Swinnerton (theo. of struct., photo.).

Analytical and Applied Chemistry—

Honors—W. G. Birrell, N. B. Brown, J. E. Clark.

Pass—F. W. Ward.

Chemical Engineering—

Honors—D. Boyd, C. E. Oliver.

Pass—S. J. Krug.

Electrical Engineering—

Honors—K. Cumming, L. L. Cunningham, L. G. Dandeno, E. G. Gurnett, G. E. Nott, A. R. Wells, H. S. Weppler.

Pass—F. C. W. Ball, F. W. Booth (thermo., mech. of machin.), R. L. Flegg, (thermo.), R. A. Fraser (hyd. lab.), S. J. Hubbert (elec. chem.), J. Kelleher (thermo., mech. of machin.), G. F. King (thermo., alt. curr.), T. R. Manning, J. Richmond, S. W. Ross, W. A. Smalser, A. E. Widdicombe.

Fourth Year

Civil Engineering—

Honors—G. A. Arksey, P. Bennett, R. H. H. Blackwell, E. D. G. Brouse, L. R. Brown, E. M. Buchanan, J. D. Cook, A. B. Crealock, E. V. Deverall, W. L. Dickson, G. A. Downey, W. R. Da Costa, W. R. Fraser, W. J. Fulton, E. R. Grange, C. E. Hogarth, C. W. H. Jackson, G. W. F. Johnston, R. E. Laidlaw, G. J. Lamb, H. O. Leach, W. E. Longworthy, C. T. Lount, R. G. Lye, C. A. Macdonald, H. E. Macpherson, W. R. McCaffery, C. R. McCort, J. P. McDonald, D. F. McGugan, W. H. Meitz, G. Mitchell, M. A. Neilson, H. S. Nicklin, R. A. Paul, H. M. Peck, C. F. Porter, J. E. Porter, G. Rankin, A. A. Richardson, H. M. Rowe, E. H. Scott, R. G. Scott, J. H. Shaw, C. N. Simpson, H. B. Thompson, L. P. Vezina, P. E. Weir, C. W. West, J. C. Wilson, H. A. Wood.

Pass—L. S. Adlard, A. C. Anderson, F. N.D. Carmichael, J. C. Christner (3rd year theo. of struct.), R. M. Cockburn, A. C. Evans, H. S. Falconer, J. W. H. Ford, C. N. Geale, (3rd year theo. of struct.), G. A. Gooderham, E. D. Gray (conditioned), G. S. Gray (thermo., 3rd yr. hydraul.), C. Hayward, E. H. Jupp, J. T. Mogan (hydraul. turb.), E. B. O'Connor, W. M. Omand, L. P. Pearce, S. M. Peterkin, C. C. Rance, J. T. Rose, J. S. Sheehy.

Mining Engineering—

Honors—W. T. Hall, J. E. Hanlon, L. T. Higgins, J. B. Stitt, J. E. C. Stroud.

Pass—E. R. Emmerson, D. S. Halford, R. D. Jones (metall., 3rd yr. metal.), F. L. Mills, J. M. Muir, J. Ross (thesis, metall.),

Mechanical Engineering—

Honors—C. G. Davey, R. H. Lloyd, W. R. McGie, A. N. Payne, F. G. Reid, A. S. Robertson, A. H. Smyth.

Pass—J. Gray, J. D. Stone, G. D. Tillson (hydraul. turb., thermo.).

Architecture—

Honors—R. W. Catto, T. S. Graham, A. Morris.

Pass—J. J. Davidson, G. R. Edwards (calc.), H. P. Frid (modelling).

Analytical and Applied Chemistry—

Honors—H. Kohl, W. D. Morris, W. Uffelmann.

Chemical Engineering—

Honors—J. E. Breithaupt.

Pass—L. G. Glass, F. J. Relyea.

Electrical Engineering—

Honors—W. V. Ball, T. R. Banbury, V. A. Beacock, H. M. Black, G. P. Davidson, W. A. Dean, J. Dibblee, R. V. Elliot, W. H. R. Gould, G. A. Ironside, G. W. Lawrence, E. M. Monteith, A. C. Ross, E. W. Savage, W. A. Steel, G. C. Storey, A. N. Suhler, A. L. Ward.

Pass—A. R. Birrell, W. H. Borus, H. C. Budd, F. H. Chandler (thermo.), W. W. Code (thermo.), D. T. Flannery, G. D. Gray, G. E. Griffiths, T. P. Ireland, K. A. Jefferson, C. M. Jones, C. R. Keys, J. S. McIntyre, E. T. Martin, (3rd year elec. chem.), W. P. P. Purdy, W. E. Russell (elec.), N. F. Seymour, A. N. Taylor.

Supplemental Examinations Passed

The following candidates have passed supplemental examinations in subjects within the brackets:—K. W. Jamieson (elec. chem.), R. A. Cross (trig., elec. lab.), W. B. Honeywell (elec. and mag.), G. S. Stratford (optics), B. MacKendrick (3rd yr. theo. of struct.), D. Sutherland (elec.), E. M. Abendana (4th yr. theo. of struct.), S. B. McGill (thesis), A. H. Parker (thesis).

Supplemental Examinations to be taken—
K. W. Jamieson (trig.), G. S. Stratford (calc.).

DIRECTORY OF THE ALUMNI

Douglas, W. E., '02, is secretary-treasurer of the McKnight Construction Co., Toronto.

Dowling, F., '05, is with the Manitoba Bridge and Iron Works, Winnipeg.

Downing, F. H., '11, whose home was at Lucan, Ont., is with the Manitoba Bridge and Iron Works, Winnipeg, when last heard from.

Duff, A. R., '09, is chemist for the Dunlop Tire and Rubber Goods Co., Toronto, in the rubber department.

Duff, M. O., '09. His last address with us is 4 Hughson St. S., Hamilton, Ont.

Duff, W. A., '01, is engineer on bridges for the Intercolonial Railway Co., Moncton, N.B.

Duggan, G. H., '83, is vice-president and chief engineer of the Dominion Bridge Co., and chief engineer of the St. Lawrence Bridge Co., Montreal.

Dunbar, W. B., '11, is with E. A. James, engineer for York County Highway Commission, Toronto.

Duncan, J. M., '10, is engineering-lieutenant, R.N., on H. M. S. "Victory" for the duration of the war.

Duncan, W. G., '13, has Port Dover, Ont., as his home address.

Dundass, C. S., '06, is at Lachine, Que., with the Dominion Bridge Co., as Draughtsman.

Dunlop, R. J., '02, is a member of the National Refining Co., dealers in dental supplies, Toronto.

Dunn, T. H., '93, is Chief Reclamation Engineer, Dominion Water Power Branch, Dept. of Interior, Ottawa.

Duthie, L. J., '09, is with the Porcupine Crown Mine, Timmins, Ont.

Dyer, F. C., '08, is lecturer in mining engineering, University of Toronto.

Eagleson, F. M., '08, is engaged in civil engineering, surveying and municipal work at Winchester, Ont.

Eason, D. E., '01, is division engineer on the construction of the Trent Valley Canal, at Peterborough, Ont.

Eckert, C. H., '11, lives at 434 Queen's Ave., London, Ont.

Eadie, L., '10, has 90 Laughton Ave., West Toronto, as his address.

Edwards, W. M., '02, is a member of the firm of Duff & Edwards, engineers and surveyors, Lethbridge, Alta.

Edwards, H. C., '14, lives at King Edward Apts., 192 Jarvis St., Toronto.

Edwards, C., '08, is with the Sewer Section, Department of Works, city of Toronto.

Elder, A. J., '04, is with the Department of the Interior, at Ottawa, in the Topographical Surveys Branch.

Elliott, C. F., '11, is enrolled at Osgoode Hall, supplementing his engineering course with one in law.

Elliott, G. R., '11, is with the Hydrographic Surveys Branch, Department of the Interior, at Calgary.

Elliott, H. F., '14, lives at Norwood, Ont.

Elliott, J. A., '14, is Assistant Engineer, B. C. Hydrographic Survey, Dominion Water Power Branch, Department of Interior, Nelson, B.C.

Elliott, H. P., '96, is a consulting engineer with offices in London and Toronto.

Elliott, J. A., '11, is engaged as chemist with the Castner Electrolytic Alkali Co., of Niagara Falls, N.Y.

Elliott, J. C., '99, whose home is at Kelso, Ont., has no other address with us.

Ellis, S. D., '14, sailed on Dec. 22nd, 1914, from Valparaiso, S.A., with a

large party of volunteers to join the British Army in Europe.

Emery, V. H., '10, is Mine Superintendent, Hollinger Mines, Timmins, Ont.

Empey, J. M., '02, is with the Department of Public Works, Calgary, as district engineer and surveyor.

Evans, J. H., '11, has no address with us.

Evans, S. D., '07, has no other address than his home at Leamington, Ont., upon our lists.

Evans, S. L., '08, was engaged in land surveying at Kamsack, Alta., when last heard from. His home is at Corinth, Ont.

Evans, W. J., '10, is in the employ of the Canadian Westinghouse Co., at Hamilton, Ont.

Ewart, J. A., '94, resides in Ottawa, Ont., where he has an architectural practice at 415 Booth Building.

Ewart, F. R., '07, is in Toronto, with the Toronto Hydro-Electric System.

Ewing, E. O., '08, is in Toronto with Frank Barber, bridge and structural engineer, 58 Adelaide St. E.

Eyres, H. E., '14, when last heard of was at 168 Antrim St., Peterborough, Ont.

Fairbairn, J. M. R., '93, is with the Canadian Pacific Railway as assistant chief engineer, located in Montreal.

Fairchild, C. C., '92, has a practice as consulting engineer and surveyor, Teglar Block, Edmonton, Alta.

Fairlie, H. W., '10, is in the employ of the Northern Electric & Mfg. Co., in their Winnipeg office.

Falconer, F. S., '00, is with the Topographical Survey Branch, Department of the Interior, Ottawa.

Falls, O. M., '14, is at London, Ont., with the Canadian Inspection Company.

Fargey, T. A., '09, was with the Canadian General Electric Co. at Winnipeg when last heard from.

Farrell, K. A., '11, is assistant engineer with Speight & Van Nostrand, Toronto.

Farquharson, W., '11, is with the Geo. R. Cook Co., contracting engineers, of Detroit.

Farelly, T. J., '11. We have not his present address. His home address is Alma, Ont.

Fear, S. L., '06, is in charge of the gas engine department of the Canada Foundry Co., Toronto.

Fensom, C. J., '03, is works engineer Otis-Fensom Elevator Co., Hamilton.

Ferguson, C. R., '10, was draughtsman with the Dominion Bridge Co., Toronto, when last heard of.

Ferguson, D. G., '14, is with the Ontario Hydro-Electric Power Commission, Toronto.

Ferguson, G. H., '05, is assistant engineer to the Commission of Conservation, Canada.

Ferguson, J. B., '09, is in Winnipeg with the C. N. Ry. in the Engineering Department, Maintenance of Way.

Ferguson, J. W., '10, is in Brampton at present.

Fergusson, A. T., '09, is a member of the firm of G. T. Fergusson & Co., stock brokers, Toronto.

Fiddes, F. R., '13, is at Detroit, Mich., with the H. W. Johns-Manville Co., in the capacity of architectural engineer at their Detroit branch.

Fingland, W., '93, is engaged in architecture. His address is 334 Portage Ave., Winnipeg, Man.

Fisken, J. B. K., '10, is with Darling & Pearson, architects, Toronto.

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THE MODERN TERROR OF THE DEEP

A Brief History of the Development of the Submarine With an Analysis of the Present Types, Their Powers and Limitations

STAFF ARTICLE

To the casual reader of the daily war news the word "submarine" conveys the idea of a type of craft of unknown dimensions that is capable of dealing, single handed, with battleships of the largest and most formidable type. Day by day we hear of the sinking of trawlers, merchantmen, passenger liners, and occasionally ships of war by these unseen terrors of the deep. No one doubts the effectiveness of this recently developed arm of the modern navy, but it has come into prominence so rapidly that we are inclined to think that the birth of the idea of such craft dates back but a few years.

The first form of the submarine was the diving bell used in the time of Alexander the Great. In 1850, William Bourne, an Englishman, is said to have developed the idea, constructing a more mobile form. Of either of these little is known, however. The reign of James I. saw the further evolution and it is stated that that monarch was a passenger in a boat built by Cornelius Van Drebbel.

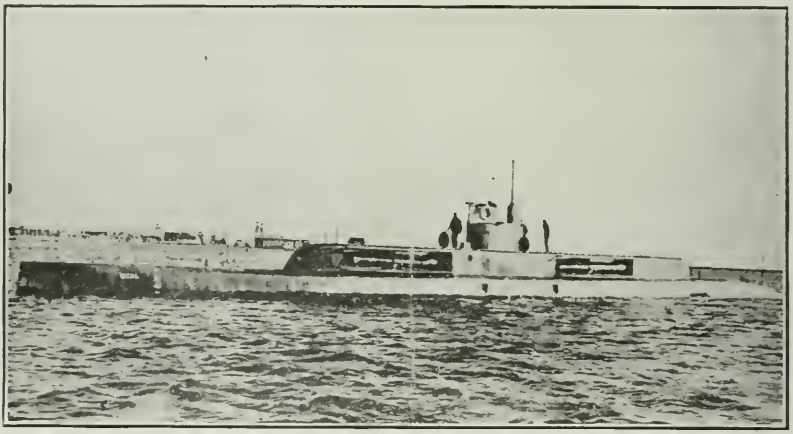
As an actual weapon of war the submarine was used in an attack on the British Battleship Ramilles off New London. This boat was of ovoidal shape, flattened at the sides and had a conning tower large enough to admit a man's head and shoulders. The crew consisted of one man, the pedal extremities of the observer being the motive power. By means of foot cranks the boat was propelled at a speed of from two to three knots. The striking power consisted of a wooden magazine fastened to the after, upper part of the hull. This carried about 150 pounds of gunpowder and was detachable. A screw, capable of being turned from inside the boat and arranged so that the outer portion could be let go forced the iron-clad magazine through the hull of the hostile craft, where it was caused to explode. The first attempt on record, that of the attack on the Ramilles, was a failure owing to the copper sheath on the hull preventing the operator of the submarine from driving his weapon home.

Between 1796 and 1810 Robert Fulton built several boats, but died before his last effort was given a trial trip. It was 80½ feet long and was propelled by a steam engine. Shortly after this the first

boat to use compressed air as motive power was built in France by Charles Brun.

In 1896 two forms of propulsion were used for the first time by M. Lanbeuf. This gave rise to the distinction between the "submarine" and the "submersible."

While all the previous attempts were more failures than successes, they laid the foundation for what may be called the modern submarine, which was first built by J. P. Holland, of Paterson, N.J., in 1899. The Holland Type of submarine is one of those used at the present time, although of course greatly developed. In 1901-1902 seven of these were launched by the United States. Their general dimensions were—length, 63 feet, 4 inches; beam, 11 feet, 9 inches; displacement, 120 tons; Gasoline engines were used when travelling



Lake Type of Submersible

on the surface and electric motors when submerged. They attained a speed of 6½ knots under the surface and 9 knots with decks awash. At this speed the radius of action was 400 miles.

As now used by the great powers there are two distinct types of under water boats. The "Submersible" is built primarily for work on the surface but is capable of being submerged. The "Submarine," on the other hand, comes to the surface only to make observations, attack by means of disappearing guns or to receive a fresh supply of air. Hence the forms of the two types differ. The submersible is built with a hull conforming to the general lines of the ordinary surface vessel, while the submarine is cigar-shaped.

The ship-shaped form of the submersible is, however, attained without abandoning the advantage of the circular section which is maintained throughout an inner spindle-shaped "strength-hull," being the form best adapted to resist the pressures of the water. Between the inner and the outer shell are water-ballast tanks and oil tanks, whence the strength-hull may be of small diameter well suited to resist great pressures without going to excessive scantlings.

The other hull, not being exposed to great pressures, may be lightly built, but will yet in some measure protect the inner hull against damage by collision. The ballast and oil tanks may, with a relatively small addition in hull weight, be made very large, whence a great reserve buoyancy and great radius of action can be secured. In a submarine the tanks are chiefly inside the strength-hull and cannot, therefore, be very large without unduly increasing the diameter of the hull and hence its tendency to collapse.

Speaking broadly the submersible has better sea-going qualities, and higher speed on the surface than the submarine, but the form is not so favorable for driving under water.

The reserve buoyancy in the early submarines was only about 5 per cent. of the light displacement but has been gradually increased to about 18 or 20 per cent. In submersibles, on the other hand, the reserve buoyancy has been reduced from about 72 per cent. in the first boat of this type, the French Narval, to about 35 per cent. or less in recent boats.

The submersible, as, for instance, the Germania type, has a relatively high centre of gravity and hence small stiffness in submerged condition on account of the high position of the tank structures, while in the surface condition the stiffness is in some cases excessively great due to the large area of the waterline. The submarine, exemplified by the Holland boats, has a low centre of gravity on account of the low-lying water tanks and therefore great stiffness in the submerged condition, but small or moderate stiffness on the surface. The Laurenti type, where the ballast tanks are partly below the strength-hull, partly above or, at least, very high, are intermediate between the Germania and the Holland type in this respect.

In order to obtain sufficient stability in the submerged condition submersibles must generally carry a considerable amount of keel-ballast. This of course is a drawback, but also most submarines carry some ballast. Part of the ballast is generally detachable, often referred to as a "safety keel," to be let go in case of emergency. In passing from the light to the submerged condition and vice versa a point will exist where the stability is a minimum, being reduced by the presence of free water in the tanks. The designer must, therefore, carefully determine the conditions of stability in all intermediate positions in order to satisfy himself that a proper metacentric height is always maintained. If the stability vanishes at any point the boat may heel over to a considerable angle before equilibrium is restored, or may even capsize.

The hull of a submerged vessel is exposed to an external water pressure which is directly proportional to the depth of immersion. Already at a depth of 200 feet the pressure is about 100 pounds per square inch, and since the depth of water in the ocean is generally more than ten thousand feet, boats cannot be constructed to withstand the pressures at all depths which they may encounter. It is therefore necessary to assign a limit to the head which a boat is required to resist. Generally there will be no object in going deeper

than required to clear the bottom of vessels on the surface, that is to a depth of about 75 feet, but accidentally boats may descend involuntarily to greater depths. Usually the head to which boats are tested is about 150 feet, in the United States Navy it is 200 feet. A certain margin of safety is, of course, applied in the construction, but if a boat goes much beyond its test depth it is liable to collapse. In most boats the strength-hull is made of circular section as stated above.

Navigation

Steering in a horizontal direction takes place as in ordinary vessels, but steering in the vertical plane has caused many difficulties to early inventors. Mr. Holland introduced diving and emerging by inclining the boat at considerable angles, while most other inventors preferred to keep the boat as nearly as possible on an even keel and to effect great changes in depth either by pumping water in or out of the boat, or by means of horizontal propellers, or by so-called "hydroplanes." The last method appears to be that which is mostly used in submersibles. Hydroplanes are similar to rudders, sometimes fitted amidships abreast of the centre of gravity of the boat, sometimes placed forward and turned the same way as the aft rudders. In all cases the object is to produce an upwards or downwards force driving the boat up or down parallel with iteslf. This method is generally considered safer than the "porpoising" used in the Holland boats. Once the desired depth is attained, it is preserved by means of the horizontal rudder in the same way as when steering a course on the surface, but with this difference that even small deviations from the given course line (depth) are not here permissible. For guidance in steering a depth gauge and a clinometer are used. Steering in the vertical plane requires considable skill and experience.

In order to navigate, the submarine boat must be provided with a reliable compass and, even when submerged, a view of the horizon must be obtainable at any time. An ordinary magnetic compass is not quite reliable even when placed in a conning-tower of bronze, but recently the advent of the gyro-compass has provided a means of accurately determinating the direction independent of magnetism. The faculty of vision when the boat is submerged, as it must be when making an attack, constitutes one of the most important and difficult problems connected with submarine boats. The water is practically opaque and it was therefore necessary in early boats, when going under water, to emerge from time to time so as to obtain a view from the conning tower, but evidently this mode of navigation was anything but safe since the presence of the boat was thus revealed to the enemy. Already in the eighties and nineties optical tubes were introduced of simple construction, invented by Marié Davy in 1854 and gradually perfected. In its simplest form the optical tube had a mirror at each end inclined at 45° to the axis. The tube, being fitted watertight in the top of the boat, projected a few feet above water when the boat was immersed and thus a view of the horizon might be obtained, but the arc of

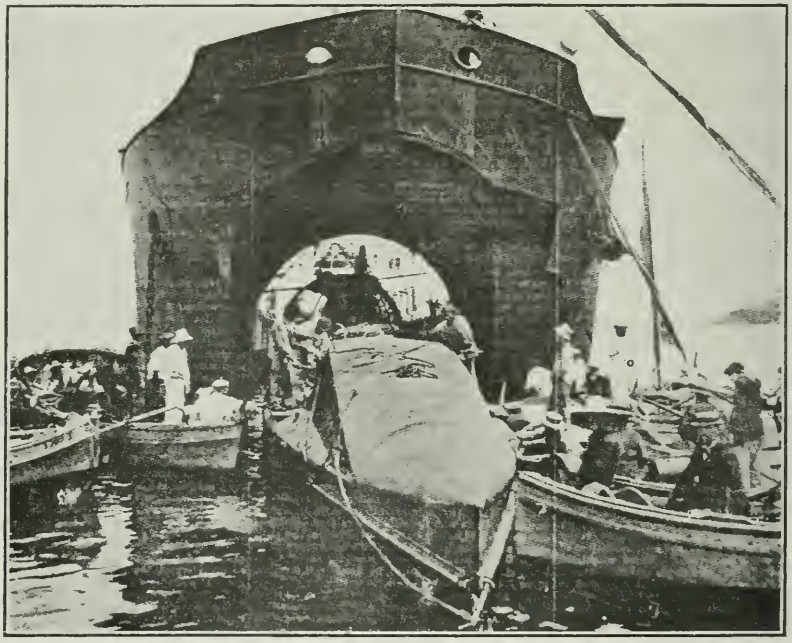
vision was at first only one or two degrees, and the image was very imperfect. The mirrors were replaced by prisms, lenses were introduced, and during the nineties several improvements were made, but not till about ten years ago was any serious progress made. Then, in a few years the optical tube or "periscope," as it is now usually called, was developed to a high degree of perfection, enabling the submarine boat to perform attacks without showing anything but the top of the periscope occasionally above water, at the same time obtaining a perfect view of the enemy. The improvements comprise a larger field of vision spanning an arc of more than 50°, as large or greater than that of the human eye, convenience of observation, and the addition of means for measuring distances and indicating directions. The magnification of the object is only about 1.5, which is found to give to the observer the same impression as when using the naked eye. By using the utmost refinements of optical art and science a perfect image of unsurpassed clearness and distinction is obtained. Mechanical power is employed for handling the tube, enabling it to be pushed up and down readily and quickly and to be turned round its axis. The length of modern tubes is up to 25 feet with a diameter of about 6 inches. The head of the tube projects from 10 to 20 feet above the hull. Difficulties still exist due to the vibration of the periscopes and spray on the front glass, but they are of secondary importance. Instruments have been constructed by which an all-round view of the horizon can be obtained without turning the tube, but have not proved quite satisfactory. The perfection of the periscope was the last link in the chain of inventions and improvements that were needed to endow the submarine boat with positive military value.

In order to go from the light to the submerged condition and vice versa it is necessary to admit or to discharge water. Main tanks of great capacity must therefore be fitted, provided with large sea-valves and powerful pumps. The water may if desired be forced out of the tanks by compressed air. The time occupied in passing from the surface to the submerged condition should not be more than about from four to five minutes. This, of course, is a point of great military importance. When a boat is completely submerged the main tanks are always entirely filled, and its weight is generally so adjusted that it falls a little below the buoyancy, leaving a tendency for the boat to rise to the surface. This tendency is overcome dynamically when the boat is in motion either by a slight inclination of the axis or by hydroplanes. The fine adjustment of the buoyancy takes place by means of a central auxiliary tank of moderate capacity used to compensate for incidental disturbing causes, such as variation in the specific gravity of the sea-water or consumption of stores. Smaller tanks near the ends of the boat permit an adjustment of the trim. Special tanks are fitted for compensating for such definite changes in weight as when a torpedo is fired and another inserted in the tube. A considerable amount of buoyancy can be obtained almost instantaneously by the release of of a safety-keel consisting of detachable blocks of lead ballast which are let go in case of emergency.

The superstructure which is above water in the light condition is self-bailing. In some boats it is built entirely and permanently open, serving only to provide a raised platform, but in most boats it is a watertight structure provided with large and numerous valves that can be readily closed when the boat is in light condition whereupon the superstructure will add to the reserve buoyancy and the stability.

Habitability

Space is always restricted in a submarine boat. When going on the surface the motor gives off much heat and requires a great amount of air for its combustion, carbon monoxide and carbonic acid, leak out from the engine. Also the men consume oxygen and



A French Transport Ship for Submarine Boats

produce carbonic acid, and when charging the batteries free hydrogen is liable to be liberated, forming with the air in the boat an explosive mixture and carrying with it particles of sulphuric acid. Where the fuel is gasoline or other volatile oil, it will evaporate at a low temperature and is liable to leak out into the boat; it is poisonous and capable of forming an explosive mixture with the air. For these reasons, it is necessary to provide a very vigorous ventilation when going on the surface. In the submerged condition, the problem would appear to be even more difficult because the available air is gradually vitiated, but it is found that with proper precautions

the crew can live for twelve hours or more without any sort of air renewal or means of purification. This is due to the constant leakage which takes place from the compressed air system, a leakage which can never be entirely prevented. If desired, the carbonic acid which gradually accumulates due to exhalation may be removed by chemical means or the foul air may be pumped out. Fresh air can be supplied as desired from the compressed air reservoirs or pure oxygen may be added. There is, however, rarely occasion for resorting to such means except in case of serious accident. A greater difficulty is the escape of gasoline and poisonous fumes from the motor as well as from the battery. There is no convenient test for carbon monoxide suitable for use in submarine boats, whence it has been necessary to use white mice for indicating the presence of this poisonous gas to the effects of which these little animals are very sensitive. White mice breathe much more vigorously than human beings and will absorb carbon monoxide about twenty times as rapidly as man. Hence, long before man feels any discomfort, the mice will show symptoms of distress. When this occurs and, especially when the mice become asphyxiated, it is necessary to ascend to the surface and to renew the air in the boat.

Life on board a submarine boat is very fatiguing and for this reason the time in which a boat can stay away from its base is very limited. The crew has to be changed at frequent intervals or it must be given time to recuperate, a fact which in many cases may limit the practical endurance of the submarine boat more than the supply of fuel. Under war conditions the crew of a submarine boat ought probably to be relieved after a few weeks' service, depending of course on the size and design of the boat and on the climatic and military conditions.

Means of Propulsion

For propulsion on the surface the gasoline motor was the first really successful engine. It was light, occupied small space as compared with the steam machinery and the combustion of fuel oil was not more than about one-half pound per H. P. hour as against at least 1½ pound per H. P. hour for steam machinery. For small boats, of a displacement of from 100 to 300 tons, where weight and space were very restricted, the gasoline engine offered the best solution, but the dangers from this volatile oil soon made it necessary to introduce heavy-oil motors, although they were in several respects inferior to the gasoline motors. While the latter are easy to start, special means are required for starting the former, and the consumption of fuel in heavy-oil motors such as those of the Koerting type was about twice as great as in the gasoline motors. The last step in the development was the introduction of the Diesel engine which likewise burns heavy oil. Although in itself rather heavy, it has a consumption of fuel somewhat less than that of the gasoline engine, and this is its principal advantage. The nominal radius of action of recent boats of the largest size, driven by Diesel motors, is given as about 3,000 miles. The speed on the surface has attained

16 knots in several boats and the designed speed in some boats now under construction is 18 or 20 knots.

The Diesel engine, then, is the motor which today finds most favor in submarine boats, but with the increasing size of boats and the claims to higher speed it becomes increasingly difficult to produce motors of this type of sufficient power. Units of from 1,300 to 1,500 H. P. with a power per cylinder up to about 200 H. P. are under construction and there are usually two and in some boats three propellers. Many difficulties are met with and failures have occurred whence steam power has been preferred in some boats as for instance in the French submersibles Gustave Zédé and Nereide of 1,000 tons displacement, which are to make 20 knots. Steam machinery has the advantages of reliability and durability, but it occupies more space and it is difficult to get rid of the heat. The radius of action obtainable with steam power on a given supply of fuel is much smaller than with Diesel motors. The weight of Diesel engines as fitted in submarine boats is about 65 pounds per H. P. as compared with about 50 pounds per H. P. for gasoline engines and from 50 to 60 pounds per I.H.P. for steam machinery inclusive of auxiliaries, propellers and shafts. The Diesel engine is being steadily improved and will no doubt be successfully adapted for larger powers in the submarine vessels of the future, but as the size and power increase, the relative advantages of steam machinery will become more pronounced.

For underwater propulsion, electric power derived from a storage battery of lead accumulators still offers the best solution. Since the first appearance of these cells they have been improved upon in many technical details, and are now reliable and durable. They will stand complete charging and discharging more than 400 times and may be expected to last about five or six years under ordinary service conditions in peace time, provided they are carefully handled. The weight per H. P. hour including outfit is by discharge in 3½ hours about 80 pounds, practically the same as in the early accumulators. Lead cells permit great variations in power and are at their best at low rates of discharge, a most valuable quality for submerged work. They can be stowed low in the boat and add thus considerably to the stability. They occupy about .4 cubic feet per H. P. hour, i.e., less than any other source of energy at present available for this purpose.

Attempts have been made to introduce accumulators of different type, the most promising of which are the Edison alcalic iron-nickel cells which have now come into serious competition with the lead cells and are to be tested in practical service on board some of the United States submarine boats. Before the result of this experiment is known, it is difficult to judge of the relative merits of the two types. It seems certain, however, that the Edison cells are more durable but more costly than the lead cells.

The total accumulated energy by storage batteries is necessarily small and rarely allows more than a speed of about 10 knots for 3 or 4 hours. Recently boats have been designed for 11 or 12 knots,

The radius of action at maximum speed of large boats is about 30 or 40 miles, but at reduced speed a radius of about 100 miles is claimed for some boats.

The electro-motors including switch-boards and leads weigh about 80 pounds per H. P. The excessive weight of the plant for underwater propulsion is the more unfortunate, since the weight available for propulsion is already very small as compared with that in ordinary torpedo-boats. The reason for this is that the hull weight is relatively great, occupying about 10 per cent. more of the total displacement than in a torpedo-boat. Only about 40 per cent. of the displacement of a submarine boat can be devoted to machinery and fuel as against about 50 per cent. in a torpedo-boat. Moreover, the plant for underwater propulsion comes as an extra addition and is practically a dead weight when the boat is going on the surface. It is evident, therefore, that submarine boats can never compete with ordinary torpedo-boats in point of speed.

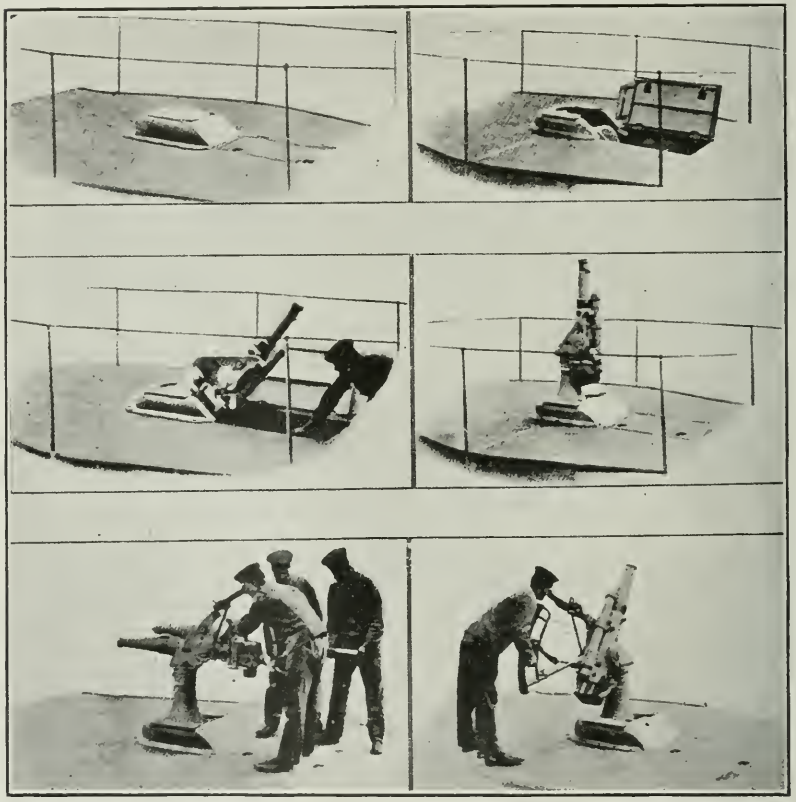
Great efforts are being made to devise a type of machinery that can be used both on the surface and submerged and especially one by which the propulsion under water does not entail any extra weight, but no satisfactory solution has yet been obtained. Any process based on combustion involves the storage of atmospheric air or oxygen, but a storage of these gases in sufficient quantities for underwater propulsion requires excessive weight and space. The discharge of the products of combustion is liable to reveal the presence of the boat.

M. d'Equevilley has proposed a solution which is being tried in the French submersible Charles Brun and probably also in a German boat. He uses an ordinary boiler with oil fuel and a steam engine on the surface, but when the boat dives under water the exhaust steam is led to a concentrated lye of sodic hydrate which absorbs the steam under strong evolution of heat and thus serves as fuel in a secondary "soda boiler." This process goes on till the lye is saturated. When the boat comes to the surface and steam is available from the primary boiler, the soda lye may again be concentrated by evaporation of the water which it has absorbed, and the boat is ready for another submerged run. This plan offers the advantages that there is no change of propelling motor, the same engine being used under water as on the surface, and there are no products of combustion. The machinery can be forced without difficulty and relatively high power attained both in light and submerged condition. No electric motor is needed. On the other hand, the system requires the addition of special soda-boilers and a hot water reservoir; the plant occupies so much space that the available weight cannot be fully utilized; the centre of gravity of the machinery is high and requires extra ballast to be carried; the radius of action on the surface is necessarily smaller than with an explosion motor, and there is likely to be a strong corrosion of the boiler due to the soda. The soda-boiler installation appears, nevertheless, more promising than other power plants so far proposed for this purpose.

Armament

The principal armament of submarine boats is the Whitehead torpedo. Recent English boats are said to carry six 21-inch tubes and French boats of the latest type eight tubes. Modern large boats are equipped with an armament of light guns in disappearing mountings. English boats carry two 3-inch or 4-inch guns so mounted that they can be used against air-craft as well as against other vessels. When not in use the guns and mounts are housed in the superstructure.

Attempts have been made to design mine-laying submarine boats, a problem which is evidently of considerable interest. As far



Disappearing Gun

as known, Russia was the only power that, prior to the war, had built a boat for this purpose, viz., the Krab, designed for dropping mines when in surface condition. It appears that the Germans are now following the example of Russia. A boat so designed that mines could be dropped when in the submerged condition would be

of greater value, but there are technical difficulties in releasing mines under water, in compensating for their weight and in determining their exact location. These difficulties have apparently not yet been overcome.

The faculty of communicating with other vessels, whether on the surface or submerged is one of great military importance for the submarine boat. For service on the surface wireless telegraphy has been successfully used for several years, but for submerged service it is only quite recently that means of signalling have been devised which promise good results. It was at first, when the submarine bell was invented, attempted to use it for signalling, but it was found that it was not well adapted for sending meassges by the Morse system. No practical solution was discovered till an European physicist showed the way by his experiments.on the transmission of vibrations through water. A wire of two inches in diameter was set into longitudinal vibrations by the friction of a hand-driven silk-wheel moistened with alcohol whereby a clear and sustained note was produced, capable of being sent in dots and dashes of the Morse code. The wire was fastened to a plate in contact with the water, and was anchored at the other end to some fixture. The tension of the wire was immaterial. An identical apparatus was fitted in one of the United States submarine boats in 1911 and readable signals were transmitted over a range of two miles. Still better results were obtained with steel ribbons and power driven exciters, by means of which distinct signals were transmitted over a distance of ten miles. Recently electrically worked oscillators have been used instead of the wire ribbons and have given very promising results. This mode of signalling is referred to as the "submarine wireless system," but it must be distinctly understood that the transmission through the water takes place entirely by sound waves emanating from a diaphragm plate which may form part of the ship's side. The receiver is a similar plate in another ship similarly connected. The invention seems now to have passed the experimental stage and signals have been transmitted under water without difficulty through a distance of fifteen miles.

As a consequence of the numerous and serious accidents which have befallen submarine boats of recent years much has been done to increase the safety of this craft. The hull is subdivided more minutely than formerly by bulkheads of sufficient strength to withstand the maximum water pressure. A buoy provided with telephone connection is fitted in the superstructure and can be sent to the surface in case of emergency, enabling communication to be established with the outside world. In some boats the men are provided with diving suits and helmets enabling them to escape or to remain for a longer time in the boat when it is flooded. Great precautions are taken to prevent the fumes from the storage battery entering the working rooms of the boat. The battery is in many boats placed in an entirely separate airtight well-ventilated compartment.

Vessels of special type, "salvage docks," are built for the pur-

pose of raising the boats when they have sunk to the bottom in damaged condition. Shackles are fitted on the top of the boats for this purpose.

Special vessels are constructed also for the transportation of submarine boats.

From the moment that submarine boats were taken into practical service, claims to increased sea-going capability, speed, radius of action, and better living conditions on board were advanced by the naval officers. Those claims could be best met by an increase in size and we can understand, therefore, that size has steadily increased ever since the beginning of the century. Boats were then less than 100 tons fully submerged and are now being built of about 1,200 tons' displacement. The reason why the displacement has not increased much faster is chiefly the difficulty of providing suitable motors for propulsion of sufficient power. By an increase in size, moreover, the boats become more difficult to handle under water, especially where the depth is small, but this difficulty is of secondary importance for ocean-going boats, which are likely soon to become a reality. The high cost of large boats will restrict their number, the price per ton being almost three times as high as for battleships.

Military Value

The great military value of submarine boats has been demonstrated in the European war. At the present stage of development submarine boats afford not only the best means of defence of one's own harbors and coasts, but may be used also for offensive purposes in the open sea and on the coast of an enemy up to a distance of at least five hundred miles from their base. The large boats of from 1,000 to 1,200 tons' displacement now under construction will have a still greater effective radius of action.

It is characteristic for the submarine boat that, once it has gotten into position, it can carry out an attack with relatively small risk to itself. In this respect it differs radically from ordinary torpedo-boats which must be prepared for great and almost unavoidable sacrifices in order to carry out a successful attack. The greatest difficulty with a submarine boat is to bring it into position for attack because the speed is relatively slow. The initiative of the commanding officer, the training, endurance, and discipline of the crew, as well as the condition of the boat and the machinery count more in submarine boats than in other warships.

The development of the submarine boat in the future is likely to be gradual. In the meantime, it is probable that also the means of attack and defence possessed by the battleship against submarine attack will progress. Evidently, the first point for the battleship is to detect the submarine boat before it has reached within striking range. If this is successfully accomplished, the attack of the submarine boat can generally be avoided because its speed under water is relatively slow. Detection of a submerged boat is, however, a difficult matter, the only visible point being the head of the periscope which needs to be shown above the surface only

from time to time. In still water the periscope is fairly visible by the wake which it makes on the surface when emerging, but in rough and misty weather it is extremely difficult to see. When the periscope is discovered, it will be at once subject to a hail storm of projectiles from light guns and, if it is hit, the boat will be blind and helpless. If, after that the boat shows the conning tower above the surface, it will be generally exposed to destruction by artillery fire.

Detection from seaplanes and other types of air-craft is under many circumstances fairly easy and this mode seems to promise a great deal. These new engines of war may possibly become deadly enemies of the submarine boat by attacking it with bombs. When a boat is submerged it is quite helpless against such attack. Even very light bombs are likely to prove destructive, and since the air-craft is in no danger of counter-attack from the submarine boat, it can go very low and hitting should not be a difficult matter. The submarine boat cannot even observe a seaplane when immediately over it. A further development of the seaplane is, therefore, likely to prove extremely dangerous to the submarine boat.

No other type of war vessel has done anything approaching the same effective work as the submarine, and from a superficial survey of the whole problem, it might be thought that this has already once and for all, solved the question of the policy which must be followed in naval design in the future. It might, for instance, be deducted that we, among other nations, must concentrate upon the construction of submarines on an enormous scale, even to the exclusion of building large capital ships. Yet it is obvious, if the matter be carefully considered, that what is undoubtedly the correct policy for one nation would be quite inadvisable in the case of another. In particular a strong naval power must always keep the offensive most clearly in view, whilst a weak naval power must necessarily rely upon defensive tactics.

Submarines, if in sufficient number, can always prevent the approach of transports, although they cannot destroy the submarines opposed to them. In fact, it seems that by a combination of a large fleet of submarines, the prolific laying of mines, and effective fort guns, it will be almost impossible for any power, however strong it may be on the sea, to allow its fleet to cover the landing of an army upon hostile shores. In other words, the submarine has added so enormously to the defensive power of any nation that in course of time an invasion by sea will become an impossibility, even in the case of those countries with a very long sea coast and a relatively small fleet.

So much has the submarine thus altered warfare that, from the purely naval standpoint, the predominant sea power could never inflict a total defeat upon a minor sea power in the sense of so completely destroying the smaller navy that a landing on a hostile coast could be effected by its aid; for even the destruction of all the submarines—a difficult enough task—would still leave the mine-fields and fort guns.

The submarine will, therefore, have a very strong influence upon military tactics in the future, and in particular for those countries which do not adjoin other countries with whom they may, under any conceivable conditions, be at enmity. It follows from this that the submarine has practically rendered Great Britain immune from invasion under any circumstances, although it should be added that our submarine fleet has not yet attained such proportions as to guarantee this condition at the present time, and when it has there is always the distinct possibility that some new method of warfare will have been developed.

Submarines cannot destroy submarines, as battleships can destroy battleships, and according to past experience it is not by any means simple for any other type of craft to bring about the destruction of submarines in large numbers. It is true we can help in this direction slightly by building an enormous number of destroyers, but, on the other hand, these are costly vessels in comparison with submarines, and the number required is so very large that one doubts if this method of attacking the submarine problem will ever be carried out on such a scale as to give security of feeling against the depredations of the submarine. The point of importance to be noticed here is that, whilst surface vessels must almost invariably act in flotillas, except, perhaps, very fast destroyers, which can escape from any slower boats, the submarine works most efficiently in single units, and this has been well shown by the recent German tactics.

The time is already here, therefore, when we should consider to what end the path along which all naval progress is tending will lead. We must open our eyes to the dangers of the future, and make preparations accordingly, not after peace has been declared, and we find we have given away some important points, but long before the question of the terms of peace is even discussed.

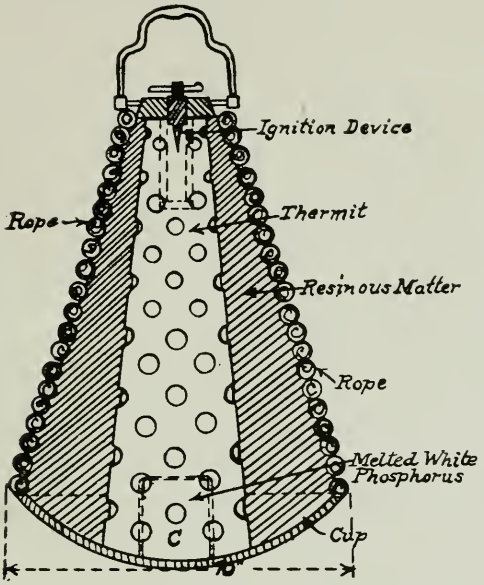
We must now and onwards continue to develop submarines in this country with more urgency than ever before, and not only must much larger numbers be built in view of possible contingencies, but progress must be made with the type of submarine constructed, particularly in the matter of speed (which means progress in Diesel engine construction), and also in the possibility of under-water craft taking the offensive on a large scale.

GERMAN INCENDIARY BOMBS

The British Fire Prevention Committee has investigated the various scenes of bomb raids in England, and has carried out tests, with the result that it has found out the nature of the bombs thrown by the aerial craft of the enemy.

An incendiary bomb is shown in section in the illustration herewith. The bomb is, as a rule, conical in shape, 10 inches in diameter at the base; it is corded around and has a metal handle at the apex. The base is a flat cup, on which a pierced metal funnel is fitted, provided at the top with an ignition device and a handle. The funnel is generally filled with thermit, which rapidly becomes

molten metal, having the extraordinarily high temperature of about 5,000 degrees Fahr. This molten metal spreads upon concussion. Outside the funnel is a padding of a highly inflammable or resinous material bound on with an inflammable form of rope. The resinous



material creates a pungent smoke. There is, further, generally some melted white phosphorus in the bottom of the cup which develops nauseous fumes. In some cases celluloid clippings are added, and occasionally a small quantity of petrol.

Fires caused by them, regardless of the extremely high temperature generated at the actual seat of the outbreak, may be prevented from spreading by applying water promptly, continuously, in large quantities, and under pressure.

LETTERS FROM GRADUATES

WHY?

The Editor—

Sir:—The "School" spirit is the strongest sentiment in the University. (We do not like the word except for its associations. "School of Science" is apt to mislead, it may be used to mislead, to emphasise a difference between "School" science and University science). Is the life of this sentiment within the individual only of four years duration, beginning in his freshman year and dying with his graduation? Is there a "School" spirit after graduation? How strong is it? How does it manifest itself?

Should there be a "School" spirit after graduation? Of what use is it?

Yours, etc.,

A Graduate.

THE HEAT TREATMENT OF STEEL

T. R. Loudon, B.A.Sc., A. M. Can Soc. C.E.

In the following discussion, it is not necessary to establish an elaborate definition of what is meant by "steel." A good general definition is that steel is the product of a process wherein the final metal has existed in a molten state and does not contain over 2 per cent. carbon. Such a definition may be disputed by the makers of the latest corrosion resisting "irons," but it should be recognized that these "irons" are merely steels very low in impurities. These arguments, however, need have no bearing on the following, because for all practical purposes as far as heat treatment is concerned, it is only the steels well known to commerce and always designated as such that need be taken into account. The only limitation that need be made in the discussion is that the carbon content of the metal must not exceed about 2 per cent. (theoretically 2.2%). Not that steels of such a high carbon content are of commercial value, but as will be seen, this is a rough limit that must be made if certain laws are to be applied—beyond this limit new conditions exist and the cast irons are dealt with.

Commercial steel ordinarily contains, besides iron and carbon, varying amounts of silicon, manganese, sulphur, and phosphorus, but the effects of these elements will be disregarded and the discussion limited to alloys of iron and carbon. It may be pointed out that for all practical purposes *this course of investigation may be pursued with safety as far as commerical steels are concerned.*

The effect of heat treatment on steel can only be understood when one has studied to some degree what is termed the *Iron-Carbon Diagram. It is not proposed in this article to go very minutely into the changes that take place in the constitution of steel during heating or cooling—rather merely to ouline the main changes and give the reader sufficient information to pursue the subject further should he so desire.*

The Iron-Carbon Diagram

Fig. 1 is a Temperature-Composition Diagram—The lines on this diagram are constructed by observing at what temperatures changes take place in iron-carbon alloys of known composition. When the positions corresponding to these phenomena are plotted and joined, the diagram as given is the result. These changes are observed by means of what are called cooling curves, which are merely time-temperature curves representing the rate of cooling. The drops in temperature during stated intervals of time are noted and plotted as a curve, and it is observed that the rate of cooling changes at certain points, in some cases the temperature remaining constant during quite an interval of time. For instance, it is found that when molten metal begins to freeze, quite a change in the cooling curve is seen. In the solid state as the metal cools, other changes in the curve are noted, which on investigation are seen to represent certain internal adjustments which are of the greatest practical importance. It is usual to investigate alloys while cooling,

but the changes noted during cooling will take place in the reverse order during heating, although the temperatures at which they take place are generally not quite the same as when cooling.

Applying to steels the method of investigation just described, if iron-carbon alloys of various known compositions be taken and melted and allowed to cool and the temperatures at which freezing (solidification) begins noted and plotted on a temperature-composition diagram, the lines AZ and ZP will result. Carrying the investigation a little further and noting the temperatures at which these same alloys are quite solid and plotting these temperatures on the ordinates representing the alloys to which they belong, the lines BX and XZ are obtained. To illustrate this, consider a steel of 1.5% carbon whose temperature line is represented by the ordinate QT drawn from 1.5% carbon on OH. This steel will be molten at any temperature above Q. At Q the metal begins to freeze and will continue to freeze till the temperature corresponding to R is reached, when the metal will be entirely solid. Reversing the process, the metal would begin to melt at the temperature corresponding to R and would continue to melt till the temperature corresponding to Q is reached, when all the steel will be molten. This illustrates roughly the freezing or melting of any iron-carbon alloy. To sum up; at the lines AZ and ZP freezing begins and at the lines BX or XZ freezing is completed; reversing the process, melting begins at BX or XZ and melting is completed at AZ and ZP. It is seen from the diagram that low carbon steels do not melt as readily as high carbon steels and that the cast iron containing about 4.3 per cent. carbon has the lowest melting point of all steels and cast irons.

It is well known that steel is not homogenous. The solid metal contains several constitutents to which names are given just as mineral constitutents are characterized one from another. The constituent that first forms when molten steel freezes is called *Austenite*, so that when the steel has entirely solidified after the freezing process, the whole mass is Austenite. The question, of course, arises as to what is the composition of this Austenite. There are two outstanding theories at present as to this composition; one maintaining that Austenite is a solid solution of iron and carbon; the other, that Austenite is a solid solution of iron and iron carbide, the carbon having formed a carbide of iron which in turn forms a solid solution with the remaining iron. The discussion of the pros and cons of these theories are of little practical interest. In the following, Austenite will be considered as a solid solution of iron and iron carbide, this carbide being represented by the formula Fe_3C. The term solid solution may be new to many and in consequence may cause a little confusion. The idea of one substance dissolving in another when liquid, is, of course, quite familiar. The term solid solution merely represents the fact that one substance dissolves in another when both are in the solid state.

Austenite, then, is a solid solution of iron and iron carbide. However, it is usual to give these two constituents distinctive names. Pure iron is referred to as *Ferrite* and iron carbide (Fe_3C) is called

Cementite, so that hereafter, *Austenite will be referred to as a solid solution of Ferrite and Cementite.* In order to investigate the changes that take place in the constitution of steel during cooling, it is advisable to take certain examples which are typical and follow out their cooling.

Considering first a steel containing, .2 per cent. of carbon, the changes that take place will be typical for all steels containing from

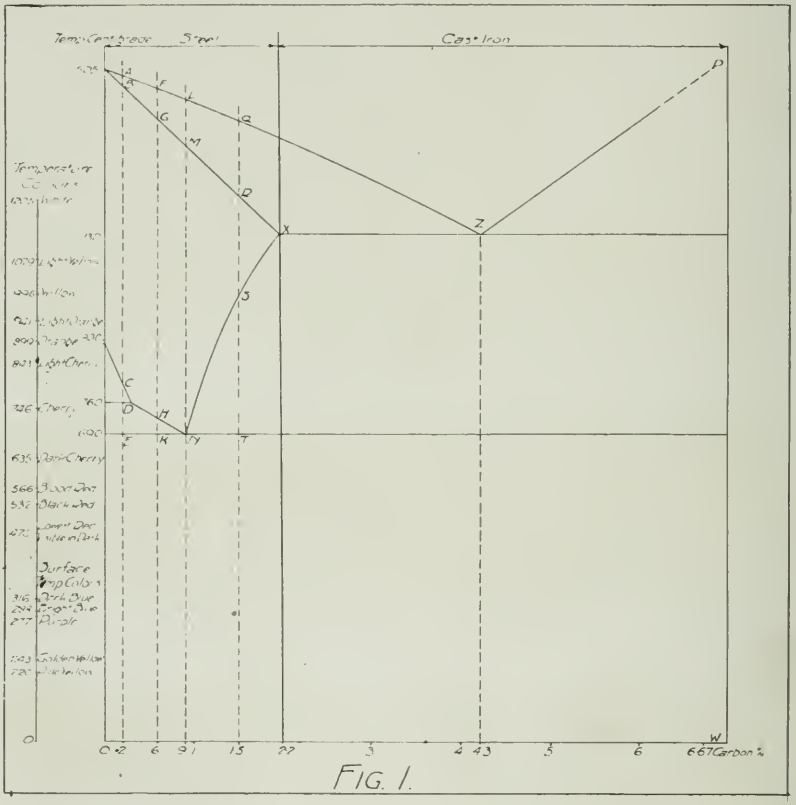


FIG. 1.

zero to about .4 per cent. carbon. The cooling of this steel is represented by the line *A.E*, Fig. 1. At *A*, freezing begins with the formation of Austenite. At *B* the metal is all solid Austenite. When the temperature corresponding to *C* is reached, Ferrite begins to segregate out of the Austenite and as the temperature drops from C to E more and more, Ferrite separates out. This ferrite that separates out is called *excess Ferrite*. At *E*, the remainder of the Austenite formation which now contains all the cementite, breaks up into its constituents, namely, Ferrite, Cementite, these two constituents forming in small plates side by side. This portion of the steel which breaks up into the formation last described is called *Pearlite*,

which we see is a formation of Ferrite and Cementite. The steel at *E*, therefore, is made up of small areas of Pearlite (Ferrite and Cementite intermingled with one another) surrounded by excess Ferrite which segregated out during the cooling from *C* to *E*.

As intimated before, it is the writer's intention to keep out as many of the intricacies as possible, but it will no doubt have been noticed that in following out the cooling of the above example of steel, that there was some change at *D* of which no mention was made. *Above D, the steel is non-magnetic, below D, the steel is magnetic.* Another allotropic change takes place at *C*, but this need not be discussed here.

Taking next a steel containing .6 per cent. carbon we have a sample typical of all steels containing between about .4 per cent. and about .9 per cent. carbon.

At *F*, Austenite begins to form and at *G* the metal is entirely solidified. At *H* the steel becomes magnetic and the excess Ferrite begins to segregate out of the Austenite. Between *H* and *K* the excess Ferrite continues to separate out; and at *K*, the remaining Austenite breaks up into its constituents, Ferrite and Cementite, giving the formation called Pearlite. The steel thus at temperatures below *K* is Pearlite surrounded by excess Ferrite.

With a steel containing about .9 per cent. carbon, solidification takes place between *L* and *M*. At *N* the steel becomes magnetic and the Austenite all becomes Pearlite.

The transformations for a steel containing 1.5 per cent. carbon will be typical for steels containing from about .9 per cent. to 2.2 per cent. carbon.

Between *Q* and *R* Austenite is formed. At *S*, on the line *XN*, Cementite begins to segregate out and continues to do so during the cooling from *S* to *T*, this Cementite being called *excess Cementite*. At *T*, the remaining Austenite becomes Pearlite. The steel below *T* is Pearlite surrounded by the excess Cementite.

It will be noticed that steels containing below .9 per cent. carbon are made up of Pearlite surrounded by excess Ferrite. Steels containing above .9 per cent. carbon are Pearlite surrounded by excess Cementite. Steel containing .9 per cent. carbon is all Pearlite, from which one would suspect that Pearlite by itself contains .9 per cent. of its own weight of carbon. This is true. When a steel has less than .9 per cent. total carbon, the Ferrite in the Austenite separates out by itself till the remaining Austenite contains .9 per cent. of its own weight in carbon, whereupon it changes to Pearlite. In steel containing over .9 per cent. carbon the Cementite separates out by itself taking with it considerable carbon, and when the remaining Austentite contains .9 per cent. of its own weight in carbon, it also changes into Pearlite.

From the foregoing, it is seen that steel contains two main constituents, Ferrite and Cementite, which group themselves in various ways to give the normal steel. Ferrite, being pure iron, is very ductile. Cementite on the other hand is extremely hard. Pearlite is a mixture of both Ferrite and Cementite, and one would

expect it to be strong and yet fairly hard. Taking these facts and applying them to the analysis of the physical properties of steels, one sees why low carbon steels containing as they do, a considerable quantity of excess Ferrite, are very ductile. As the carbon content of the steel grows, the steel contains more and more Pearlite and in consequence becomes higher in tensile strength but loses in ductility due to the lessening proportion of Ferrite. After .9 per cent. carbon is passed, the excess Cementite makes the steel harder and more brittle, the tensile strength also dropping off.

It must be clearly understood that the changes outlined throughout the above are those that take place under normal cooling. In other words, a piece of steel must be allowed to cool at a fairly slow rate if the normal conditions in the steel are desired. *Interference with the rate of cooling, such as chilling, for instance, will greatly effect the properties of the steel.*

The Grain Size of Steel

The granular structure of steel is best seen by observing a polished section under the microscope, although it is possible to get a comparative idea by observing the fracture, especially in the high carbon steels. Overheating steel above a certain temperature has a great effect on the grain size, and as grain size is more or less a direct indication of the strength and ductility of steel, it is important that the cures for overheating be understood.

The higher a piece of steel is heated above about 690°C. the coarser will be the grain size. (It may be pointed out that normally the grain size of low carbon steels is larger than high carbon steels). This coarsening of the grain size by overheating has the following effect: Low carbon steels lose in strength but do not seem to have their ductile qualities effected materially.

Medium and high carbon steels lose both in strength and ductility. Tool steels, for instance, when badly overheated become so weak as to be readily broken if tapped very lightly with a hammer.

The effect of overheating may be counteracted in two ways:—

(1) Work the steel mechanically as it cools from a high temperature.

(2) Heat refine the steel.

To apply the mechanical method, the steel must be forged or rolled as it cools. The effect may be roughly explained by saying that the forging or rolling breaks up the coarse grains. The mechanical work should theoretically be kept up till the steel has cooled to the temperature of the lines *C H N T*, Fig. 1, for if stopped at a temperature above this, the grain size will grow again till these temperatures are reached. The effort of engineers is to get the steel manufacturer to have the temperature at which rolling is completed as close as possible to these temperatures. In many cases, there is no doubt that the finishing temperature of rolling mills is too high, the result being a coarse grained and weakened steel. With forging, on the other hand, the work is generally continued to a lower temperature, as a forge hammer does not require as great an expenditure

of energy and consequently money, to produce the required effect as does a rolling mill.

If a piece of steel has been overheated and allowed to become cold, and it is desired to restore the grain size mechanically, it is only necessary to reheat the steel and forge or roll it.

It is seen that besides shaping a piece of steel, rolling and forging has another very important function, namely, *the production of strength by reducing the grain size of the steel.*

Obviously, there are many commercial steel shapes that do not lend themselves to work being done on them by either rolling or forging. Steel castings, for instance, furnish a good example. Many structural shapes also may be overheated subsequent to their manufacture, and in order to restore their grain size it would be impossible to forge them, much less roll them again. So then, if the grain coarsening effect of overheating is to be overcome, some other method must be resorted to. This other method is known as Heat Refining. In order to heat refine the grain size of a piece of overheated steel, the metal must first be cooled below 690°C. For low carbon steels from zero to .7 per cent. carbon, reheat the steel till the line *C H N* is reached. For high carbon steels from about .7 per cent. carbon up, reheat to about 725°C. The effect of this reheating is to break up the original coarse grain size and produce a new fine grain formation. Researches show that if a piece of steel be allowed to cool below 690°C., that on reheating a new grain formation starts on recrossing the temperature 690°, and this new formation of small grains will obliterate the old formation of large grains. This is a rough explanation, but it contains the principle of the process. As to the reason why the lower carbon steels have to be reheated higher than high carbon steels this would require more space for explanation than is at our disposal. The best practical example of the application of heat refining is seen in the heat treatment of steel castings. If it is necessary to make a low carbon steel casting of good ductility, it is usual to "anneal" it. Strictly speaking, "to anneal" means to slowly cool, but it is easily seen that *any amount of slow cooling will not refine the grain size.* A steel casting on cooling is extremely coarse grained, having cooled from a very high temperature above 690°C. In order to get a fine grained casting, it is always necessary to first cool below 690° and then reheat as explained above. Eye-bars for bridges are also often heat refined to make sure that the steel is as ductile and strong as possible. It is not out of place to point out here that there is a curious and persistent fallacy often expressed even to-day; namely that "vibration or shock will crystallize a piece of steel." There never has been any evidence that the grain of steel is coarsened by such treatment and to suppose that such treatment produces steel of a granular structure is an absurdity. Steel is always granular in formation. As to the growth of grain size due to such treatment, it is more than likely in every such case that the steel was coarse grained due to faulty manufacture and this fact was only discovered when the fracture occurred.

Generally speaking, no growth of grain size takes place below 690°C. However, there seems to be one exception to this in the case of very low carbon steels containing below .1 per cent. carbon. These steels if held for a long time at temperatures between 500°C. and 740°C. will have the grain size enormously enlarged and the metal becomes very weak. This phenomena is called "Stead's Brittleness" after J. E. Stead, who discovered it.

Burning of Steel

The external evidence of what is known as burnt steel is seen in the peculiar sparking of the metal at high temperatures. A slight amount of surface burning may not injure a piece of steel, but in any event the effect is certainly not beneficial. *Low carbon steels can be heated much higher without being burnt than can high carbon steels* such as used in tool making.

The burning is simply an oxidation of the steel. In badly burnt steel, the grains of steel become surrounded with oxide films, thus greatly and permanently impairing the strength.

Forging seems to do away with any injurious effect when the steel is only slightly burnt. This explains no doubt, why rivets which are often slightly burnt are not badly reduced in strength. However, as the writer heard one well known steel man say, the best way to do away with the bad effects of burnt steel is not to burn it.

Hardening Steel

Under normal conditions, the higher the carbon content of a steel the harder the steel. If a steel be heated to any temperature above 690°C. and cooled suddenly, it will become much harder than when in a normal condition. The rule quoted above as to the relation between hardness and carbon content also applies in this last case when cooling is accelerated. The higher the carbon content, the harder the steel will be when cooled suddenly. If the carbon content be below .2 per cent., however, it is doubtful if the increase in hardness of a steel cooled suddenly over a normally cooled specimen can be noticed by ordinary methods, such as testing with a file. Above this percentage of carbon the increase in hardness becomes more and more noticeable till the tool steels are reached.

In order to obtain the greatest possible strength with hardness, care must be taken not to heat a steel to too high a temperature above 690°C. It is true that hardening will be produced if cooled suddenly from any temperature above this, but it must be kept in mind that a high temperature above 690°C. will coarsen the grain size, thus reducing the strength. The best combined effect of hardening and strength is given at the temperatures of the line *C H N* for steels below .7 per cent. carbon and at about 725°C. for steels above this percentage of carbon.

The rate of cooling is of great practical importance when hardened steel is desired. *The faster a steel is cooled from above 690°C., the harder it will be.* Quenching in ice brine gives a very hard

steel. Quenching in pure water at ordinary temperatures will harden the steel but not so much as ice brine. Quenching in oil gives a softer effect. By a judicious use of cooling medium, various degrees of hardness can be produced.

Tempering Steel

Tempering is a term nearly always misused. To temper a steel means to lessen the effect of hardening. Generally, the hardening and tempering are both classed together and referred to as tempering. *If a steel has been hardened, it may be tempered by being slightly reheated.* To understand the principle of tempering, what takes place during hardening must be investigated.

When a steel cools at a normal rate, we have seen that certain changes and adjustments take place. If the rate of cooling be hastened, sufficient time for these changes is not allowed and a condition which is not normal is brought about and maintained, the quick cooling making the metal too rigid to allow the normal changes to take place. At least this is a very satisfactory general way of viewing the situation. If now, the steel is slightly reheated, the rigidity of the metal is loosened and the normal changes will either be wholly or partly brought about, depending upon whether or not the steel be again quenched, thus again stopping the changes which may be taking place.

To summarize the tempering process; if a steel has been hardened, it may be either partially or wholly softened by reheating. The effect of this reheating may be stopped at any stage by simply cooling suddenly when desired.

A very convenient method of judging to what temperature a piece of steel has been reheated for tempering, is my means of observing the temper colours. If the surface of the steel be slightly polished it will be noticed that oxide colours form between 200°C. and 300°C. The temperatures corresponding to these colours are shown on Fig. 1. It is not necessary to reheat beyond any of these temperatures in order to temper a steel.

It may be pointed out that quenching in liquids, such as oil, which takes away heat slowly, gives practically the same effect as may be had by quenching in water and then tempering. When heat is abstracted by the oil, it is not taken away at such a rate as to entirely stop the normal changes from taking place. Cold water on the other hand, may almost entirely stop these changes, but the tempering allows them to slightly take place, thus arriving at the result obtained by oil hardening.

To illustrate the hardening and tempering of a cutting tool, the cold chisel gives a very good example. About one and a half inches of the tool are heated to a cherry red and then one half of this heated portion is quenched in water. The heat from the remainder is then allowed to flow into the quenched and hardened portion, thus tempering it. If the temper colours be observed, the

yellow will be seen moving slowly down to the point and the blue will be a short distance behind. This indicates the temperature of the steel and when these colours have gone far enough down the metal, the tool is quenched. Thus a good hard cutting edge may be obtained with the steel grading back to normal tough metal. The natural question at this stage is, when should the tempering be stopped? A very few trials will give the needed experience. If a cold chisel be taken and experimented with, the reader will very soon be able to judge for himself when to stop the tempering operation in order to get the proper hardness and toughness.

For rough work, the colours of the steel for given temperatures are shown on Fig. 1. This method of judging temperature by the eye is, of course, only good for rough work. When accurate results are required, pyrometers are used, and indeed, to attempt any other method would be out of the question.

PERSONALS

J. L. Alton is now with Highways Branch, Department of Public Works, Toronto.

E. T. Austin, B.A.Sc., '09, is with the Mond Nickel Co., Coniston, Ont.

E. G. Archer, B.A.Sc., '11, is with the Hydro Electric Power Commission, Toronto.

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R. H. Armour, '05, present address, care of S. Armour, 345 Jarvis St., Toronto.

G. A. Arksey, B.A.Sc., '15, with the Toronto Harbor Commission, Toronto.

W. F. M. Bryce, '08, is assistant engineer, city engineer's department, Ottawa, Ont.

G. G. Bell, '05, is chief engineer for West Pennsylvania Traction Co., 1st-2nd National Bank Building, Pittsburg, Pa.

J. H. Billings, M.A.Sc., '11, has received his degree of Master of Applied Science from both the Massachusetts Institute of Technology and Harvard University. Present address, Leskard, Ont.

D. C. Blizzard, B.A.Sc., '09, is at present at 16 Manor Road, Rugby, England.

W. V. Ball, B.A.Sc., '15, is shell inspector for Goldie & McCullough Co., Galt. His address, 40 West Main St. N., Galt.

V. A. Beacock, B.A.Sc., '15, is with the Hydro Electric Power Commission Toronto.

F. M. Buchanan, B.A.Sc., '15, is working on the Wayne County roads, Michigan. His address is 47 Goldsmith St., Detroit.

A. M. Campbell, B.A.Sc., '04, is erection engineer for the Toronto Structural Steel Co. Residence, Weston, Ont.

P. G. Cherry, B.A.Sc., '11, present address, 63 Pauline Ave., Toronto.

J. Clark, '00, is with the Turnbull Elevator Works, Toronto. His address is 129 Garden Ave., Toronto.

L. S. Cockburn, B.A.Sc., '10, has recently accepted position as heating engineer with the Glass Garden Builders, Toronto. His address, 201 Church St., Toronto.

J. Chalmers, '94, has been elected an officer of the Edmonton Branch of the Canadian Society of Civil Engineers for 1915-16.

Norman S. Caudwell, '10, of the town of Prescott and solicitor of the Supreme Court, has been appointed notary public in and for Ontario.

R. M. Cockburn, B.A.Sc., '15, is field draughtsman on the Toronto Harbor Commission.

A. B. Crealock, B.A.Sc., '18, is field draughtsman on the Toronto Harbor Commission.

Fred C. Dyer, B.A.Sc., '08, present address, 241 Melita Ave., Toronto.

E. V. Deverall, B.A.Sc., '15, with the Dominion Bridge Co., Toronto, as draughtsman.

MODERN MILITARY EXPLOSIVES

J. W. Bain, B.A.Sc.

The most casual reader of the newspapers must have noticed among the despatches from the front, such items as, "The French fired 30,000 shells in a two hours' attack," but it may be stated with certainty that few of those who glance over the reports have any idea of the elaborate preparation which must be undertaken before the shell is sent upon its death-dealing mission. Not only must the shell be very accurately made as far as dimensions and weight are concerned, but it must be propelled and burst by the use of materials which demand a tedious and very careful manufacture. It may not be out of place at this time to discuss these modern military explosives, during which brief discussion it is hoped that certain outstanding facts may be emphasized.

Gunpowder as it has been known to Europe for the last five hundred years, plays a minor part in the present conflict

The smoke which accompanies its explosion has a very obvious drawback from a military standpoint, and the concealment of guns, so strikingly shown in many illustrations recently published, has been rendered possible by the use of smokeless explosives. With the exception of small quantities of gunpowder used in the fuse of a shell and as a bursting charge in shrapnel, the powder of our fathers' days may be said to have been abandoned.

As a propelling charge in guns and rifles of all sizes, smokeless powders are almost universally used. These are mixtures of gun-cotton, nitroglycerine and a thick mineral oil such as vaseline; and a few words may be said as to their manufacture.

That an explosive oil could be obtained by mixing glycerine with nitric and sulphuric acids has been known since 1847 when an Italian chemist discovered the fact accidentally.

This substance, nitroglycerine, was, however, too dangerous to handle in its liquid condition, and Nobel conceived the happy idea of absorbing it in some porous material producing the familiar explosive, dynamite. The shattering property of the latter is well known to every one, and this material is consequently of no value as a propelling agent in a gun.

It was, however, discovered in recent years that if gun-cotton—which will be discussed later—were kneaded with nitroglycerine in the presence of a small quantity of acetone or camphor, there resulted a doughy mass which could be handled safely and at the same time worked up into a valuable propellant, exploding without smoke.

This is, in brief, the process of manufacturing the British *Cordite*, so-called because the dough is squeezed through dies under heavy pressure and reeled into cords which are afterwards cut to convenient lengths. The diameter of these cords is varied to suit the use for which the powder is intended, the larger the gun, the thicker the cord, and in some instances, the mass is moulded into large prisms or cylinders. Powders of this type varying slightly in composition, size and method of manufacture are used by all the

present combatants, and the supply must be adequate, or a retreat such as the Russians have just made is inevitable.

For the bursting charge in high explosive shells, picric acid or trinitrotoluol are the most widely used. Picric acid is obtained by the action of nitric and sulphuric acids upon carbolic acid, the latter a product of the distillation of coal tar. Under ordinary conditions, a yellow powder burning quietly in the open, melts at 122°C, and may be poured without danger in the shells where it solidifies as a dense yellow mass; such shells may be handled without special precaution and are prepared for use by the addition of a fuse. This consists of a somewhat elaborate timing device containing a thread of gunpowder which burns at a definite rate and leads to a small quantity of fulminate of mercury, which detonates violently on heating. The picric acid is curiously sensitive to such detonation and explodes with the greatest violence, liberating quantities of yellow fumes which are frequently referred to.

Trinitrotoluol is prepared by the action of nitric and sulphuric acids on toluol, a liquid hydro carbon, which, like carbolic acid, is a product of the distillation of coal tar. Trinitrotoluene burns quietly with a smoky flame, and only explodes violently when detonated with fulminate of mercury. It melts at about 80°C and can, consequently, be handled more conveniently than picric acid which melts at 122.5°; the latter has the additional disadvantage of emitting quantities of yellow, acrid fumes during the fusion which renders the loading process very unpleasant. Picric acid has also the drawback that it forms with many metals, highly explosive salts, so that for safety sake, the interior of the shell must be varnished, and the explosive is further protected by a paper lining. Trinitrotoluol does not suffer from these disadvantages. It may be interesting to note that the Dominion Steel and Iron Company at Sydney, B.C., are turning out about 500 gals. of toluol per day for the manufacture of this explosive, the final stages being carried out elsewhere; as far as the writer is aware, no picric acid has been made as yet in Canada.

For the destruction of bridges, earthworks, masonry, etc., and as a charge for torpedoes, gun cotton is widely used. This is made by the action of nitric and sulphuric acids on cotton, the product resembling closely the original fibrous material. After a very thorough washing, it is compressed into blocks and stored with a content of about 17% water. Like the two explosives mentioned above, it is fired with a fulminate charge; commonly a small amount of dry gun-cotton is also used, which permits the amount of the fulminate to be reduced.

These four explosives may be regarded as the most important in use at the present time; others are being employed without doubt, but their manufacture and properties cannot be considered here.

It will be noted that the raw materials used for the preparation of these four substances are as follows:

Sulphuric acid, Carbolic acid,

Nitric acid,	Toluol,
Glycerine,	Cotton,

and each of these will be referred to briefly in turn.

Germany has produced in recent years very large quantities of *Sulphuric acid*. To manufacture this substance, sulphur of some sulphides are essential; the former is not found native in quantities in the territory of the Dual Alliance. There are, however, considerable quantities of sulphides; and in the newly-conquered Belgium, the Austro-Germans have acquired control of large bodies of zinc blende, an ore in common use for the manufacture of sulphuric acid. It may be concluded, therefore, that the supply of this acid is adequate.

Nitric acid has until ten years ago, been made exclusively from sodium nitrate imported from Chile, where it is found native. This source being cut off, the Germanic Allies have had to fall back upon the nitric acid made from the air by electric furnace methods. The latter have been highly developed in Norway owing to the cheapness of water power, but there are well founded reports current that steam power is being used in Germany for the same purpose. Taking the most favorable yields which have been made public, one horse power year will yield 1¼ tons of pure nitric acid, and Norway's total production is estimated at 300,000 tons. When the enormous plant which would be necessary to generate 100,000 horse power by steam is considered, the writer is forced to the conclusion that only a quarter or a third of the requirements of the Germanic Allies can be produced within their own territory by the processes under consideration.

Ammonia can be converted into nitric acid and without difficulty and this is being done beyond question in Germany at present. No data are at hand which permits a calculation as to the output from this source, but for various reasons which cannot be detailed, the writer believes that 100,000 tons per annum is the maximum at present.

We have then a maximum probable supply of nitric acid sufficient for the manufacture of 1,000 tons of explosives per day.

Glycerine is obtained by boiling the natural fats or oils with caustic soda, or by treating these with steam under pressure. In 1912, Germany imported glycerine or its equivalent in fats to the extent of 19,000 tons; the loss of these imports can only be made up by oils or fats obtained in the territories of the Dual Alliance. Here, again it is difficult to estimate the available supply, but the writer believes that a shortage in glycerines is inevitable. It is not unlikely that substitutes for nitroglycerine in the manufacture of smokeless powder, will be or are being used, and the shortage alluded to above would not have any serious effect on the supply of munitions.

Carbolic acid and toluol, as has already been noted, are obtained from coal tar, or from coal gas. The conversion to the corresponding explosives is comparatively easy from a chemical standpoint, and here the Germanic Powers have a decided advantage. Everyone is familiar with the great coal tar dye industry of Germany, and their

great plants can be adapted for the manufacture of these explosives on a few days' notice. The same apparatus which is used in making the dyes, can with a few minor changes, be turned to the production of picric acid or trinitrotoluol, while the Allied Powers are forced to build many of their factories from the ground. The immense advantage which this has given to the Dual Alliance, shows only in more marked relief, their inability to deal the crushing blows which were to decided the issue.

Carbolic acid and toluol can be made in very large quantities in Germany and Austro-Hungary; there seems to be little prospect of the shortage in these substances. *Cotton* has been so prominent a factor in the maritime warfare that but little need be said. When the amounts of cotton in the possession of one household are remembered, it is not difficult to conclude that very large contributions can be made by private citizens should necessity arise, but here again the picture holds only the prospect of lessening supplies. Whether wood pulp or paper which like cotton, is almost pure cellulose, can be used in its place, still remains to be seen, but much can be done under stress, and gun cotton will not fail as an explosive for some time to come.

In conclusion, some data and calculations may be of interest. Sixteen cartridges for the British service rifle contain 1 pound cordite, or, 1,000,000 cartridges contain 31 tons. The French 75 mm. gun uses 5 pounds of explosives for each explosive shell; 100,000 shells involve the expenditure of 250 tons. A 12 in. British gun requires 189 pounds of explosives per shot, or 10½ rounds per ton of explosive,

The writer has amused himself in making some guesses as to the daily consumption of explosives upon the various battle fronts, with only the vague data of occasional reports as a basis. What quantities have been expended by the Germanic Allies in Galicia and Poland since May is even beyond guessing, for practically no information has appeared; we are merely informed that the consumption has been enormous. The impression which is produced in our minds is that exhaustion of the supply is approaching, but we must bear carefully in mind, that our journalists feed us sedulously with the most optimistic scraps of information, and that we have as yet no information, direct or indirect, that the Dual Alliance is failing or is likely to fail for some time to come in its supplies of explosives.

F. R. Ewart, B.A.Sc., '07, is a member of Ewart & Jacob, electrical engineers, Room 306, 156 Yonge St.

Gerald Galt, B.A.Sc., '07, is metallurgical engineer for the Braden Copper Co., Rancagua, Chile, South America.

Norman R. Gibson, B.A.Sc., '01, present address, 550 Confederation Life Building, Toronto.

J. M. Gibson, '10, is taking out his captaincy papers at Niagara.

Wm. W. Gunn, B.A.Sc., '09, present address 243 Quebec Ave., Toronto.

R. D. Galbraith, B.A.Sc., '15, is on mechanical designing for the Curtiss Aeroplane Co., Toronto.

G. D. Gray, B.A.Sc., '15, is inspecting shells for the Canadian Inspection Co. His address, 40 West Main St. N., Galt.

Geo. S. Gray, B.A.Sc., '15, is on harbor construction work for the Canadian Stewart Co., Toronto.

THE WORK OF THE ENGINEERING SOCIETY OF THE UNIVERSITY OF TORONTO AND ITS COOPERATION WITH THE FACULTY OF APPLIED SCIENCE

Dean W. H. Ellis, M.A., M.B.

The founders of the University College Literary and Scientific Society had in mind an organization for the discussion of subjects of interest to the students of both literary and scientific character, but the scientific side was always a dead letter and that body from the first became purely a debating society.

The late W. B. Murrich, M.A., LL.B., at one time president of the society endeavoured to stimulate the scientific side by giving a medal for a scientific essay, but without any permanent effect in changing the character of the Society.

In its own way and after its own fashion, the society played a very important part in university life. It afforded a means of social intercourse to the students, gave them opportunities of becoming acquainted with the conduct of public business and practice in public speaking, as well as other advantages of much value.

The students of the School of Practical Science recognized the value of such an organization and a band of enterprising and public spirited students, prominent among whom was Dr. T. Kennard Thomson, organized a society in the School in the year 1885. The first President being the Principal of the School, Professor Galbraith. Thus from its inception the Faculty and the students have been closely associated in the Engineering Society. As soon, however, as the Society was fairly on its feet, it chose a President from among the students and Mr. H. E. T. Haultain was elected to this position. From that time till now the President of the Engineering Society has been a student.

Although it has been implied that the idea of the Engineering Society was suggested by the University College Literary and Scientific Society, the former is no slavish imitation of its older sister, but was organized and has developed on quite distinct lines. It aims to be and is a professional society and its papers are all of a technical character, in most cases relating the experience of the author. A number of very valuable papers have from time to time been contributed by graduates and many good papers have been given by undergraduates, based on their vacation work.

In addition to this many useful and stimulating lectures have been given by engineers of eminence on subjects on which they were recognized authorities, thus giving the students a first hand acquaintance with the conditions of modern engineering as understood and practiced by its engineers occupying leading positions in this and other countries. The business meetings of the Society and its various committees afford to the student training and practice in the conduct of public business, which many of them have found of great value in after life.

Some years ago the Society undertook to sell to its members on the co-operative system the various instruments and materials

required by students of Engineering and this Supply Department has had a flourishing career for several years.

There is one feature of the Engineering Society which calls for special notice, this is its representative character. In a very special sense the Engineering Society may claim to represent the students of the Faculty of Applied Science, in fact the Engineering Society is an embodiment of the undergraduates of the Faculty of Applied Science and can speak for them with no uncertain voice. By a wise provision the fee for membership of the Society is included in the dues payable by each student to the Bursar, and hence every student in good standing is a member of the Society.

It may be assumed therefore with more than usual confidence that a resolution of the Engineering Society expresses the opinion of the undergraduates of the Faculty of Applied Science and the most direct way of reaching the ears of the student body is through the Engineering Society.

The existence of this thoroughly representative body with a democratic organization of its own, has been and is of the greatest value with regard to the relations between the teaching staff and the students of the Faculty.

Many things that cause friction between the governors and the governed do so because of mutual misunderstanding, the saying tout savoir est tout pardonner, though not the whole truth contains more thuth than most sayings of its kind, and any thing which helps to make clear to the student what the Professors really mean and to the Professors what the students really think is of the greatest value.

Ten minutes chat between an official of the Faculty Council and an officer of the Society will often clear up misunderstandings that might otherwise have become quarrels and developed into harshness on the one side and mutiny on the other.

The Engineering Society in this way is looked upon by the Faculty Council as a most valuable ally in the task of maintaining the orderly and efficient working of the academic machinery. It is and has been a power working in the interests of peace and good will.

In addition to all this the Engineering Society publishes a journal "APPLIED SCIENCE."

This is the most ambitious and perhaps on the whole the most creditable of its many activities. The Society may point with justifiable pride to the volumes of "APPLIED SCIENCE" which have appeared since its inception in 1907. Graduates and undergraduates, professors and students have joined in the endeavour to make this publication worthy of the University and of the Faculty which it represents and their labours have been rewarded with no small measure of success. No one who knows anything of the conduct of a periodical of this kind will be surprised to learn that its upkeep makes a heavy demand on the financial resources of the Engineering Society. To keep the journal up to the standard which its promoters have had in mind demands considerable effort and sacrifice on behalf of the Faculty of Applied Science and its friends. It is to the graduates of the university in Applied Science that the executive of the Engineering Society and the editorial staff must look for support in this undertaking and they confidently expect that they will not look in vain.

SHRAPNEL*

Similarities and Differences in Leading Types of Shells

Shrapnel shells, as used at the present time by the several governments, vary slightly in construction and general contour as well as in the constituents entering into their different members. A completed shrapnel, as illustrated, consists of a brass case carrying a detonating primer and the explosive charge for propelling the projectile out of the bore of the gun; a projectile, which is a forged shell carrying lead bullets and a bursting charge; and screwed into the front end a combination timing and percussion fuse which can be set so as to explode the shell at any desired point and from which the flame for exploding the bursting charges is conveyed through a powder timing train and a tube filled with powder pellets down through the diaphragm to the powder pocket.

Shrapnel shells are made in two distinct types, the common, and the high-explosive. The high-explosive shell is not ruptured upon the explosion of the bursting charge in the base, but the head is forced out and the bullets are shot out of the case with an increased velocity. In the meantime, the head continues in its flight and detonates on impact. This type of shell is not used quite so extensively as the common shrapnel, and for simplicity of description the latter alone will be taken up in the following.

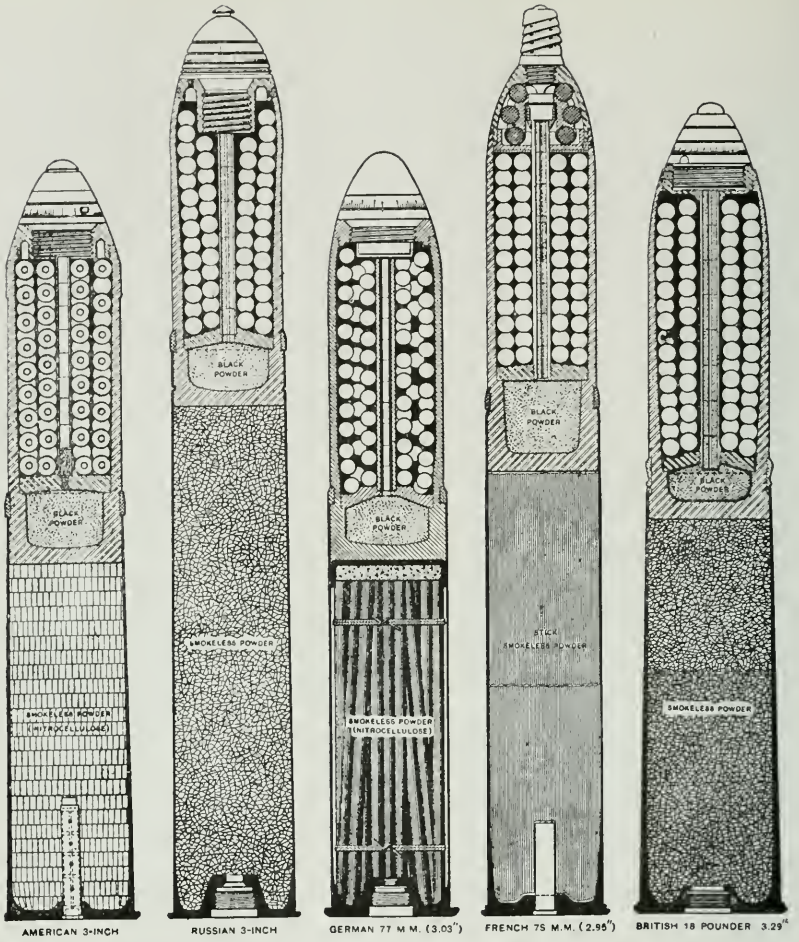
So far as the construction of the shrapnel shell and case is concerned, there is little difference in those employed by the various governments. The form of the explosive charge held in the brass case differs in almost every instance, but smokeless powder in some form or other is used. The detonating agent or primer held in the head of the case also varies in almost every type of shrapnel. Practically all primers are provided with "safety heads" so that the shrapnel can be handled without danger of premature explosion.

The shell itself, as previously mentioned, is made either from a forging or, in the case of American and French shells, from bar stock. Forgings, however, are used to a greater extent than bar stock, because the forged shell is more homogeneous in its structure than the bar stock shell, and piping is entirely eliminated. Near the base of all shells is a groove in which a bronze or copper band is hydraulically shrunk. This is afterward machined to the desired shape and takes the rifling grooves in the gun so as to rotate the shell when it is being expelled.

The bursting charge, common black powder, is carried in the base of the shell and is usually enclosed in a tin cup. Above this is the diaphragm which is used for carrying the lead bullets out of the shell when the bursting charge explodes and distributes them in a fan shape. In most shells, upon exploding, the nose blows out, stripping the threads that hold the members together. It will therefore be seen that, in the explosion, the entire fuse, fuse base, tube, diaphragm and bullets are all ejected, the shell itself acting as a secondary cannon in the air.

The range of a 3-inch shrapnel shell is about 6500 yards, and the

*Machinery.

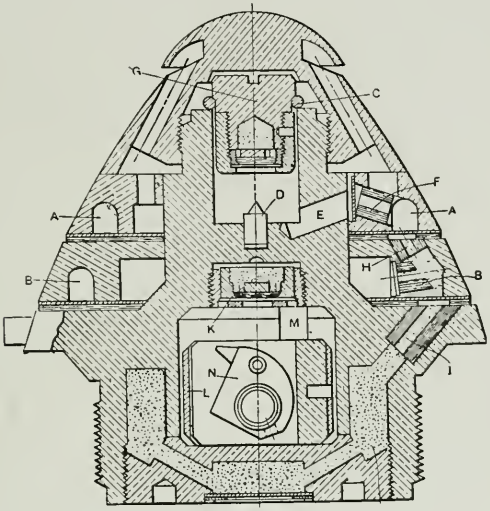


SECTIONS THROUGH TYPICAL SHELLS OF LEADING NATIONS

muzzle velocity of the quick-firing field gun ranges from 1700 on the American to 1930 feet per second on the Russian. The duration of flight ranges from 21 to 25 seconds. When the bullets are blown out of the shell by the bursting charge, they are given an increased velocity of from 250 to 300 feet per second. The velocity of the shrapnel at 6500 yards is about 724 feet per second. The number of lead bullets carried in the 3-inch shrapnel shells ranges from 210 to 360. In all cases, the lead bullets are about ½ inch in diameter, weight approximately 167 grains, and are kept from moving in the shell by resin or other smoke-producing matrix.

The matrix put in with the lead bullets, in addition to keeping them from rattling, is also used as a tracer. It is of importance in firing shrapnel that the position of the explosion be plainly seen. With large shells this is not difficult, but with shrapnel for field

guns at long range certain conditions of the atmosphere make it difficult to see when the shell actually bursts. Various mixtures are used to overcome this difficulty. In some cases fine grained black powder is compressed in with the bullets in order to give the desired effect. In the German shrapnel a mixture of red amorphous phosphorus and fine grained powder which produces a dense white cloud of smoke is used, and in the Russian, a mixture of magnesium and antimony sulphide is used.



American Timing and Percussion Fuse

The most common fuse is that known as the combination timing and percussion fuse of the double-banked type. This is used in practically all shrapnel fuses except the French. The manner in which the combination timing and percussion fuse is regulated to discharge the bursting charge in the shrapnel shell is interesting and involves extremely difficult mathematical calculations. Before going into the method of setting the fuse, it would probably be advisable to describe briefly just how the fuse operates. An example of the double-banked fuse is that adopted by the American government, here illustrated. The following description applies to this type of fuse.

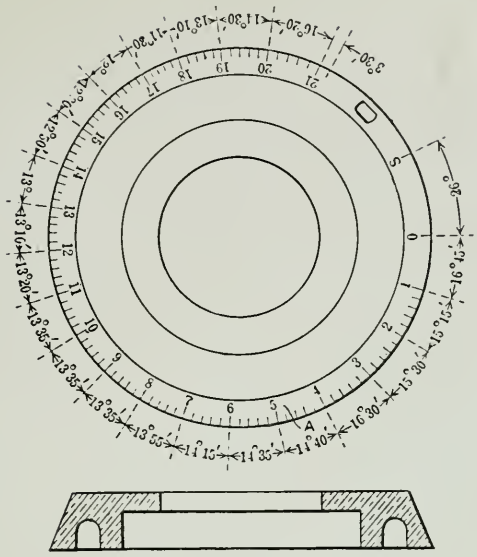
Assume first, that the timing ring is set at zero. The propelling force given to the shrapnel shell in leaving the bore of the gun is such as to sever the wire *C* from the plunger *G*. The plunger *G* carries a concussion primer which is discharged by hitting a firing pin *D*. The flame passes out through the vent *E*, igniting the powder pellet *F* and the upper end of the train A, and then through the vent *H*. From here, the flame is transmitted to the lower timing ring *B* through the vent *I* and the magazine *J*, and from there through the tube to the bursting charge in the base of the shrapnel shell.

Assume any other setting, say 12 seconds. The vent *H* is now changed in position with respect to the vent *F* leading to the upper timing train, and the vent *I* leading to the powder magazine *J* is also changed. The flame, therefore, now passes through the vent *E* and burns along the upper time-train *A* in a counterclock-wise direction until the vent *H* is reached. It then passes down to the beginning of the lower timing train and burns back in a clockwise direction to the position of the vent *I*, from which it is transmitted by the pellet of compressed powder in this vent to the powder magazine *J*. It should be understood that the annular grooves in the lower face of each timing train do not form complete circles, a solid portion being left between the grooves in the ends of each. This solid portion is used to obtain a setting at which the fuse cannot be exploded and is known as the "safety point." As shown it is marked *S* on the adjustable timing ring.

The timing fuse shown is of the combination timing and percussion type, and if the wire *C* fails to release the percussion plunger *G* the shell is exploded by means of a percussion fuse which comes into use when the shell strikes. The percussive mechanism consists of a primer *K* held in an inverted position in the centre of the fuse body by a cup located beneath the percussive primer. The percussion plunger *L* works in a recess in the base of the fuse body and is kept at the bottom of the recess away from contact with the primer by a light spring in the plunger *M*. The firing pin *N* is mounted on a fulcrumed pin, and is normally kept in the vertical position by means of two side spring plungers. When the shell strikes, the impact causes the plunger to snap up against the primer after compressing the spring in the pin *M*. This causes the firing of the primer *K* and the explosive charge passes out through a hole in the percussion plunger chamber, not shown, to the magazine *J* and from there down to the powder in the base of the shell.

With the exception of a few minor details, the timing fuses used in the American, Russian, German, Japanese, etc., shrapnel shells are the same. The French timing fuse, however, operates on an entirely different principle.

The timing ring used on the American fuse is illustrated. Here it will be seen that the ring is provided with 21 graduations corresponding to 21 seconds in the duration of flight of the projectile. It will also be noticed that the spacing of the graduations differs. For instance, *S* to *o*, or safety to *o*, occupies 26 degrees. This, as previously mentioned, is required so that the ungrooved surfaces of the timing rings can be swung around far enough to bring them in line with the vents for firing. From 0 to 1 is greater than from 1 to 2. The reason for this is also in the relation of the vents. From 3 to 4 will be seen another variation. This takes into consideration the positions of the lower timing train and the trajectory of the flying missile. From 6 seconds around to 18 is practically a constant drop, taking into consideration the decrease of velocity, and from 18 on, the graduations begin to increase for two reasons: the decrease in the velocity of the missile and the action of gravity.



AMERICAN TIMING RING

In manufacturing shrapnel shells, a test shell is taken from every 120 and is actually fired out of a quick-firing gun into a bank of sand. If the contour of the shell in the neighborhood of the powder pocket is expanded during this test, the shell is discarded because of the liability of tearing out the rifling grooves in the gun.

INTERNATIONAL ENGINEERING CONGRESS

Those of our readers who anticipate visiting the Panama Exposition, will do well to try and arrange to be in San Francisco from September 20-25 for the International Engineering Congress. Never has there been such a representative assemblage of engineers.

The materials of engineering construction will receive special attention and the field will be treated under eighteen or more topics, covering: timber resources; preservative methods; brick and clay products in general; life of concrete structures; world's supply of iron; life of iron and steel structures; status of copper and world's supply; testing of metals, etc.

These papers will be contributed by engineers eminent throughout the world, and will be published as volume 5 of the transactions. This volume will form a most valuable acquisition to the library of all engineers and others who may be interested in these phases of engineering.

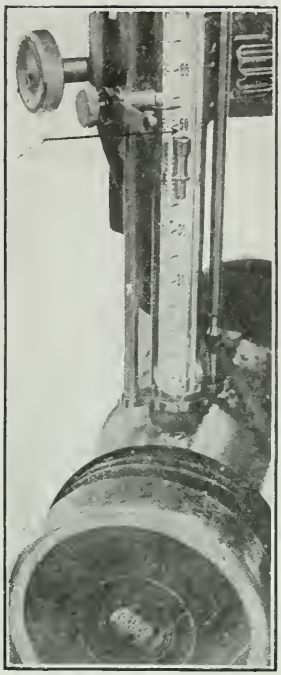
For further information and a copy of the booklet which outlines the programme and prices of the transactions, apply to

W. A. Cattell, Sec.,

417 Foxcroft Building, San Francisco, Cal.

THE SCLEROSCOPE

R. J. Marshall, B.A.Sc.



The supplying of munitions to England has introduced a great many new problems to the Canadian manufacturer. This business like any other special line of machine work has a whole host of difficulties which have to be overcome before the finished shells can be supplied with a certainty which means successful production.

Almost the first of these difficulties to be met and overcome in the production of shrapnel shells is the mastering of the heat treatment. The steel forgings have a tensile strength varying from 75,000 lbs. to 90,000 lbs. per sq. inch before the heat treatment. This stress is raised from 125,000 to 200,000 lbs per sq. inch by heating the shell to a temperature of about 1,500° F. and quenching it suddenly in oil at 100 °F. This operation would be simple if the treatment could be exactly specified and if the material had a uniform chemical composition, but unfortunately the steel cannot be produced uniformly enough to allow the treatment to be given in precise and definite terms. Therefore the manufacturer has had to gain his own experience by experimenting and sometimes by making mistakes. A treatment which would prove successful with .45 carbon would probably cause a steel of .55 carbon to fail in passing the physical specification. The manganese, sulphur, phosphorus, silicon and nickel are the other chemical constituents which must also be considered in selecting the treatment. Each variation in the chemical composition necessitates slight changes in the heat treatment.

It is unfortunate that during these critical times our Canadian manufacturers are compelled to learn the arts of munition making. Some English Parliamentarians have surely forgotten that experience in these arts is essential before production can be forced. This seems to be a reasonable explanation of why our manufacturers were not able at first to produce the quantity of shells desired.

To heat treat a shell is one kind of a problem, but to know what effect the heat treatment has had on the steel is another problem of an entirely different kind. The elastic and tensile properties are the standard of comparision, but of course it is impossible to cut selections from all shells for tensile tests, therefore the manufacturer

had to find some method of following the changes made by heat treating without damaging the surface of his shell. The instrument which has proved the most successful in this regard is the scleroscope.

The scleroscope consists of a small hammer with rounded diamond of known radius in the striking end, which is raised pneumatically in a glass tube to a height of about 11 inches. This is dropped on the surface to be tested and rebounds, the operator noting the amount of rebound on the scale attached to the glass tube; the reading on the scale is called the scleroscopic reading. The principle made use of in the calibration of this instrument is the physical relationship between the tensile and hardness properties of steel. A steel which has high tensile properties will offer a harder surface to the impact of the hammer than one which is low in tensile strength and the harder of the two surfaces will give the greater reading.

Some of the scleroscopes have a scale of tensile strengths opposite the scleroscope scale, but the tensile scale is not at all to be depended upon for reasons that will be outlined later in this article. It becomes necessary then for the operator to calibrate the scleroscope scale relating his readings to tensile tests. Pieces which have been carefully scleroscoped and which range in reading from say 35 to 55, are made into tensile test pieces and tested in tension. By comparing tensile strength with the War Office specification the safe range is found and that is compared with the corresponding scleroscope readings.

The scleroscope reading of 45 for instance, is not by any means an infallible indication of a definite tensile strength. If for example, the hammer is dropped on the same spot a number of times successsively, higher readings will be obtained. The first drop of the hammer makes a small mark, and succeeding readings enlarge the area. The amount of rebound is a function of the area of the indentation made; as the area increases the rebound will also increase.

The smoothness of the surface on which the hammer is dropped has also a bearing on the height to which the hammer will rebound. A rough surface will not give as great a reading as one perfectly smooth. Also the rebound depends upon how the piece being tested is placed under the scleroscope. If it is loosely placed on a light anvil, the reading will not be as great as if placed in a solid holder. The chemical composition of the steel also effects the reading obtained. For one set of chemical figures a reading of 45 on the scleroscope would represent a stress of say 130,000 lbs. per sq. inch, but for a different chemical composition the scleroscope reading of 45 might represent only a stress of 110,000 lbs. per sq. inch.

These fallacies in the scleroscope are submitted as evidence supporting the contention that the instrument is an aid to a close inspeciton of the steel, but it should not be taken as an infallible method of testing the tensile properties of the shell. Properly calibrated and frequently checked, the scleroscope should be indispensable to the business of producing shell.

UNIVERSITY OF TORONTO CLUB OF NEW YORK

On the evening of April 22nd, the University of Toronto Club, of New York, held its annual meeting, which was preceded by an informal dinner.

During the meeting attention was called to the notice recently sent out in regard to the University of Toronto Military Hospital, equipped for service at the front, and a committee appointed of which Mr. W. J. K. Vanston was elected chairman. The meeting was brought to a close with reports from E. W. Stern, '84, J. S. Galbraith, B.A.Sc., '13, and others, on the work being done by the University students and graduates in connection with the war. Mr. Stern's remarks related largely to the work of C. H. Mitchell, '92, at the front, while Mr. Galbraith spoke more particularly about military affairs at Toronto.

Among those present were: President Louis L. Brown, '95, and past presidents, Dr. T. K. Thomson, C.E., '86, T. H. Alison, B.A.Sc., C.E., '93, H. F. Ballantyne, B.A.Sc., '94, E. W. Stern, '84.

After the routine business the following officers were elected for the year 1915-16:—President, Dr. E. R. L. Gould; vice-presidents, Mr. C. V. Campbell, Mr. John Langton, Dr. R. G. Snider; secretary-treasurer, Mr. H. F. Ballantyne, '94; membership committee, Dr. J. E. Bowman, H. P. Rust, '02, and A. LeR. Chipman.

Mr. H. F. Ballantyne is following the example of Dr. T. K. Thomson, as he has been appointed secretary-treasurer for another year.

EXAMINATION SUPPLEMENT

Fourth Year—A. H. MacQuarrie is now eligible for the degree of B.A.Sc.

Third Year—H. R. Hopkins and C. E. Gage have completed the third year examinations.

B. B. Hogarth, B.A.Sc., '14, is assistant engineer on the Alberta and Saskatchewan Power Survey, Water Power Branch, Ottawa.

H. O. Hill, B.A.Sc., '07, now at 315 Western Ave., Aspinwall, Pa.

Chas. T. Hamilton, B.A.Sc., '07, is a member of the firm of Johnston & Hamilton, engineers and contractors and Dominion and B.C. land surveyors, 73 Exchange Building, 142 Hastings St. W., Vancouver.

A. N. Hunter, B.A.Sc., '08, is connected with the Canadian Inspection Co. at Detroit. His address is care of Detroit Rounding Co., Jefferson Ave. W., Detroit.

W. T. Hall, B.A.Sc., '15, has accepted a position with the Braden Copper Co., Rancagua, Chile, South America.

L. T. Higgins, B.A.Sc., '15, has also gone to South America with the Braden Copper Co., Rancagua, Chile.

C. E. Hogarth, B.A.Sc., '15, is reinforced concrete inspector on the Welland Ship Canal at Port Weller.

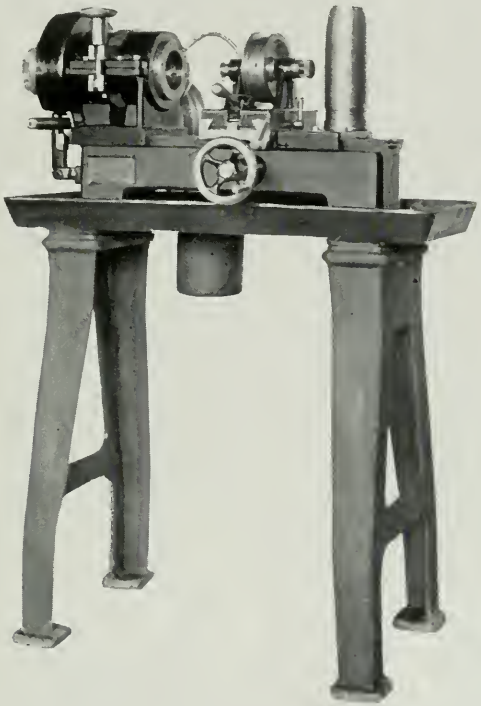
L. G. Ireland, B.A.Sc., '07, has been appointed manager of the Brantford Street Railway in addition to the office which he has previously held as manager of the Hydro Electric System of Brantford.

R. V. Jones, B.A.Sc., '15, is inspector for the Beaver Mine.

R. H. Johnston, B.A.Sc., '10, now residing at 10162 116th St., Edmonton, Alta.

A NEW THREAD MILLING MACHINE FOR HIGH EXPLOSIVE SHELLS

This machine has been developed by a Canadian manufacturer, and sold very rapidly to all leading shell manufacturers. It occupies a floor space of 2 feet by 3 feet and stands 4 feet high. The shell is placed inside the revolving spindle and automatically centred. The cutters are made of high speed tool steel and are of special design,



which eliminates the change of form when sharpened, and mills the top of the thread as well as the depth. It is fitted with an oil pump and fully equipped for work. This machine eliminates all risk of having shells rejected because of stripped threads, as is so often the case when tapped by the old method.

One operator can run several machines, as they are almost automatic. The output is greatly increased by having two machines, one to thread the nose and one to recess and thread the base. A perfect thread is produced in the nose in 2½ minutes, and the base recessed and threaded in the same time. These two machines will finish a shell every 2½ minutes, or 240 in a day of 10 hours.

Prices and terms for this machine will be furnished upon application to the manager of Applied Science, Engineering Building, Toronto University.

UNKNOWN ADDRESSES

Our readers will confer a favor if they will kindly advise us of the correct, or most recent known address, of any of the men listed below

Acres, H. G., '14.
Alexander, J. H., '04.
Beatty, W. G., '01.
Berry, E. W., '10.
Bertram, G. M., '01.
Binns, R. E., '13.
Blair, W. J., '02.
Boswell, W. O., '11.
Bowman, A. M., '86.
Brackenreid, '11.
Brown, D. B., '88.
Brown, H., '11.
Brown, E. W., '09.
Bruce, W. J., '07.
Burnham, F. W., '04.
Cameron, M. G., '09.
Campbell, A. J., '04.
Campbell, A. W., '06.
Campbell, J. E., '08.
Campbell, R. J., '95.
Carey, B., '99.
Carscallen, H. R., '08.
Chambers, E. V., '14.
Chantrell, E., '05.
Charlebois, J. P. C., '08.
Chisholm, D. C., '10.
Christie, F., '06.
Clendenning, A. C.
Coulter, G. P., '07.
Darroch, J., '08.
De Guerre, F. C., '11.
Derham, W. P., '09.
Dowling, F., '05.
Elliott, J. C., '99.
Evans, J. H., '11.
Evans, S. D., '07.
Flynn, C. C., '11.
Foreman, W. E., '99.
Forester, C., '93.
Francis, C. C., '08.
Galletly, J. S., '07.
George, R. E., '03.
Gourlay, W. A., '03.
Heebner, M. B., '11.
Horton, J. A., '03.
Hull, H. S., '95.
Johnston, G. K., '03.
Jones, G. R., '06.
Kean, D. J., '09.
Keefer, A. H. E., '09.
Keys, W. R., '08.
Killip, W. C., '08.
Lawson, W. L., '92.
Lott, A. E., '87.
McCuaig, O. B., '04.
Macdonald, F. R., '08.
Macdougall, A. C., '01.
McKay, A. G., '07.
McKay, J. T., '02.
McKenzie, D. W., '05.
MacLachlan, W. A., '09.
McLean, W. N., '05.
McLeod, G., '09.
McMordie, H. C., '08.
McPherson, J. A., '06.
Macpherson, N. W., '09.
McTaggart, A. L., '94.
Maisonville, A. W. R., '10.
Malone, J. E., '08.
Martin, F., '87.
Matheson, W. C., '01.
Maus, C. A., '03.
Mennie, R. S., '02.
Milligan, G. L., '08.
Mitchell, L. C., '11.
Montague, F. F., '06.
Munro, F. V., '03.
Murray, J. D., '07.
Niebel, E. H., '11.
Nourse, A. E., '07.
O'Brien, E. D., '05.
O'Gorman, C. A., '09.
Oliver, J. P., '03.
Parke, J., '04.
Paton, T. K., '07.
Paulin, F. W., '07.
Pearce, K. K.
Pearson, C. L., '11.
Pope, A. S. H., '99.
Raymond, D. L. C., '04.
Roaf, J. R., '00.
Robertson, D. F., '03.
Sanders, W. K., '06.
Sauder, P. M., '04.
Scott, W. A., '06.
Shipley, A. E., '98.
Shortt, J. H.,
Smiley, R. W., '97.
Smith, J. H., '03.
Squire, G. E., '11.
Stamford, W. L., '08.
Stuart, J. L. G., '07.
Szammers, C. F., '11.
Taylor, J. W. R., '08.
Taylor, W. V., '93.
Thomas, V. C., '08.
Thomson, J. E., '06.
Williamson, D. A., '98.
Wilson, F. F., '09.
Wilson, W. H., '10.

Editorial

SPECIAL ISSUES —ATTENTION CLASS 1903!

In a subsequent issue of Applied Science the management intend outlining definitely the policy of this magazine; and in the meantime propose, by a plebiscite, to deal with the advisability of continuing to publish Applied Science, and methods of making it a more effective and efficient medium among "School" men. A very worthy suggestion has come from a member of class 1903 and it is our intention to act upon it. Special editions of Applied Science will be published every three months, as special year numbers, devoted to articles contributed by members of that year. Each year will be advised through these columns, from three to six months in advance of the date of publication, of their issue, and as many as possible communicated with by letter.

The first special issue will appear in November and will be got out by class 1903; and each and every member of that year is asked and being depended upon to contribute his share. Do not think that we will have enough material without yours, and that you are too busy. Every man can write an article on some line of work, if not engineering, he can contribute some current or personal news.

In order to avoid duplication of articles by different members in the same issue a date will be set in the letter each will receive, at which date the editor will require the names of the articles to be contributed.

It is to be generally understood by all our graduates that these special numbers will appear every three months and any year may be called upon at any time. The friendly rivalry and competition thus created among the different years should result in a great deal of added interest in Applied Science and in subsequent issues becoming better.

EMPLOYMENT BUREAU

In each issue of Applied Science appears a full page advertisement asking graduates to send in their name and particulars of experience, but few have done so. So few, indeed, that one would think that all had work, or at least were satisfied with what they had. This, in normal times, is scarcely ever the case, much less in the present crisis. There are many without work at all and many not satisfied with what they have, and still the help of the Engineering Society is not solicited.

The employment bureau has been reorganized and can, with the co-operation of the graduates seeking employment, be made of great value. On the other hand a file having but a few applicants for employment is worse than none at all. Conditions are improving as the following will show. During June and the early part of July we could have placed a School man as mine surveyor in Ontario, as assayer in Quebec, as mechanical designer, as assistant electrical engineer on city of Toronto Rapid Transit, as mechanical engineer

with Underwriting Company, a mechanical man as editor of a Canadian mechanical journal, and others, which we had to let go after going through our files and finding but few graduate applications in each section. This is a very regrettable fact, particularly this year, as many men would be glad of such positions, and it is very poor advertising for the Faculty of Applied Science and the Engineering Society.

The Editor has got in touch with the British representative, at present in Canada securing mechanics and engineers for munition work in Great Britain, and in the near future expects to place a large number of such men. Should any of our graduates desire such work or further particulars, it is advisable to make application at once to the editor.

SUBSCRIBERS IN ARREARS

All subscribers to APPLIED SCIENCE in arrears have received two circular letters during the past two months, in which the financial position of the Society was set out as fully as was consistently possible, anticipating that all would realize our situation and pay their dues. However, the response was very meagre indeed. So meagre, in fact, that there must be some reason.

It may be that in the rush of work the bill has been set aside with all good intentions and forgotten, as it is such a small amount. On the other hand it may be that you have received the magazine so long without being asked to subscribe that you began to feel that you were entitled to it as a graduate, and that you do not feel disposed to pay for something you had not asked for. If this latter is the case and you would be kind enough to advise us to discontinue sending the magazine to you, the Editor will write off your arrears. In offering to do this the management feel sure that few of our graduates view it in that light, although it must be acknowledged that it was poor business to let the matter run as it has.

There are others who, as life members of the Engineering Society, have expected all publications of the Society, and no doubt have been somewhat at a loss to understand why they should be billed for the magazine. In explanation, it might be said that this particular section of the constitution was changed some years ago, so as not to cover a life subscription to APPLIED SCIENCE, and it is to be regretted that members affected by this had not been advised. In the light of this explanation there is no doubt that everyone will only be too glad to pay up.

The management are sparing no pains to get, methodically, the general opinion of all our graduates on APPLIED SCIENCE and thereby hope to greatly increase the efficiency of the magazine in consolidating that "School" spirit of which we are all so proud. Not one can afford to be without this paper; but all our subscribers must be paying subscribers or something radical will have to be done.

As a result of the considerable correspondence of late in the technical and lay press on cast iron shells, we have been striving to

get an explanation of why the Allies do not use cast iron shells as the Germans are doing, and thereby increase our output. To those unable to apply critical examination this method of production may seem highly desirable. However, "The Engineer" of recent date contains an editorial, the deductions of which are based on an actual and critical examination of a piece of a German cast iron shell and raises the following objections, which are very interesting and instructive.

CAST IRON vs. STEEL SHELLS

"There are several objections to such shells. In the first place, where shrapnel is concerned, the number of bullets is reduced because the walls of the projectile must be made much thicker. In the case of high-explosive shell, this does not apply in so great a degree, because the walls of the steel shell are then made thicker than is necessary for strength, but there is such danger of a cast iron shell developing cracks during manufacture that high explosives cannot safely be used in them. It must be remembered that no risk of a shell bursting in a gun must be run, and no one will doubt that there is more risk in cast iron than there is in forged steel.

"Another point against cast iron is connected with accuracy of fire. To ensure this, the projectile must be perfectly in balance. The walls must not only be of exactly the same thickness all round, but they must be homogeneous. At the very high speed of revolution set up by the rifling, a small difference of weight to one side of the centre line would be quite sufficient to cause irregular shooting. With forged steel there is little or no difficulty in securing this balance; with cast iron there is always some danger of local porosity, which, besides being a source of weakness, would destroy accuracy.

"Moreover, if the projectile were cast on a chill core and was not machined internally, a risk of the core not being absolutely concentric would always have to be faced. Accurate fire would then be impossible. To remove a chill core, even if it were collapsible, it would be necessary to have a large hole in the base of a high explosive shell, of which the point is always solid, which subsequently would have to be plugged. If a sand core were used it might be removed through a smaller hole, but the machining of the interior would be difficult owing to the shape of the ogival head and the smallness of the hole through which the tool must be entered. In the case of shrapnel the boring would be much easier, because a large opening is left for filling purposes, but, owing to the small number of bullets that could be carried, cast iron shrapnel cannot be considered.

"All these facts have militated against cast iron shells, and although, of course, cast iron and cast steel were used at one time, they have entirely given place to forged steel. Furthermore the methods of manufacture of steel shell have been so developed that such shell can actually be turned out more quickly than those of cast iron of equal reliability and accuracy. An 18-pounder shell for example, can be completely machined from the bar in about forty minutes. The case for the forged steel shell is, then, complete, and there is no case at all for the cast iron shell.

A Case of Necessity

"The answer is fairly obvious, as to why Germans are using cast iron shells. In spite of the greatness of the supplies of their modern guns and projectiles, the Germans are beginning to find them not inexhaustible under the tremendous drain that is being put upon them. Hence, guns and projectiles have been drawn from stores many years old to fill up the deficit in modern supplies. The guns use a lower powder pressure, which the cast iron is able to stand, and the shells are probably filled with black powder, so that less danger is to be feared from an accidental burst. We believe this to be the real reason for the fragment of a cast iron shell being found on the battlefield.

"Whether the Allies also are using old guns and shell we cannot say, but it is not inherently improbable. Every nation concerned has been surprised by the part artillery has been called upon to play, and it is not unlikely that all of them have drawn upon resources of every kind that can be turned to account. If the Germans are indeed using cast iron, it is a favorable sign, for it shows that even they, with all their preparation, were unable to collect enough material of a modern kind to meet the requirements of the war.

However there are those who do not deny the impossibility of firing a cast iron shell accurately but believe that it might be used effectively to break down trenches, etc.

A GRAND PRIZE

We take great pleasure indeed in drawing to the attention of our readers the fact that one of our advertisers has received the only medal of honor awarded for rail joint products in the Transportation Department by the Panama-Pacific International Exposition at San Francisco. We refer to the Rail Joint Company of New York.

SUPPLY AND DEMAND

The Wall Street Journal of recent date contained comparative figures showing the remarkable increase in the cost of the various munitions of war. Most of the prices it quoted are the same as those at present prevailing in Canada, and as will be seen, are causing considerable concern to the military authorities. Powder has increased in cost over 25%, rifles approximately 50%; and other ammunition 30%. Unless the supply of such commodities as copper, antimony, lead, the acids, etc., which are necessary for the manufacture of these, is increased, there will be still further advances. For spot or early delivery almost any price can be obtained.

We notice the greatest rise in picric acid, which is used in enormous quantities in the manufacture of the French powder, melinite; the British explosive, lyddite, and the Japanese powder, shimose. In fact every grade of powder which has salt petre as a constituent

shows a sharp advance, as do all the explosive acids, with the exception of nitric acid.

On the other hand, however, dynamite which is used extensively for war purposes, has not increased in cost, but this may be due to the fact that it is more or less an article of commerce.

KEYS—BASSENBERGER

Conrad Roy Keys, B.A. Sc., '15, to Alvena Dorothea, daughter of Mr. and Mrs. Frank Bassenberger, of Berlin, Ont., at Toronto, April 13th, 1915. Mr. and Mrs. Keys will probably reside in Toronto.

ROBERTSON—MacKAY

At the home of the bride's parents, Weston, Ont., on June 2nd, 1915, Arthur S. Robertson, B.A. Sc., '14, son of Mr. and Mrs. S. Robertson, Toronto, was united in marriage to Irene, daughter of Mr. and Mrs. P. J. MacKay.

HOWARD—LOUDON

We have to announce the marriage of Mr. John T. Howard, B.A. Sc., '13, son of Mr. and Mrs. Willson Howard, of Madison avenue, with Miss Ruth Loudon, daughter of Mr. and Mrs. W. J. Loudon. Mr. and Mrs. Howard have gone to the States and after a holiday up the Georgian Bay will settle in 223 St. Clements avenue, Toronto.

MUNTZ—WELLER

Eric Percival Muntz, B.A. Sc., '14, son of the late V. G. Muntz and of Mrs. Muntz, Toronto, to Marjorie Louise, second daughter of Mr. J. L. Weller, engineer in charge of the Welland Ship Canal, at St. Catharines. Mr. and Mrs. Muntz will reside at Port Weller.

ON ACTIVE SERVICE

W. P. Murray, B.A.Sc., '08, has joined the Canadian Overseas Railway Construction Corps.

R. H. Hopkins, B.A.Sc., '06, has been appointed signalling officer of 39th Battalion at Belleville.

C. V. Perry, B.A.Sc., '14, with the 2nd Canadian Contingent in the Cyclist Corps.

Lt. J. L. Whiteside, B.A.Sc., '10, with 46th Battalion at Sewell, Manitoba.

Corp. A. T. McPherson, '16, **Pte. G. S. Stratford,** '16, **Lieut. D. G. Hagarty,** '16, **Pte. J. A. Simmers,** '18, **Pte. P. A. Laing,** '05, **O. G. Lye,** '14, with the Second University Overseas Contingent.

Lieut. L. S. Adlard, B.A.Sc., '15, is at Niagara Camp on the staff looking after the water supply.

E. R. Grange, B.A.Sc., '15, formerly on mechanical designing with the Curtiss Aeroplane Co., Toronto, has enlisted for active service with the Aviation Corps.

Lieut. Col. C. H. Mitchell, '92, has been recommended by Sir John French for distinguished conduct.

Lieut. H. F. H. Hertzberg, '07, of the Canadian Engineers, who was reported as wounded in the last issue, has recovered and just recently returned to the front. He has been mentioned in dispatches from the front and has been awarded the Military Cross.

Lieut. Elliott A. Greene, '11, of the 9th Battery, Canadian Artillery, has also been recommended by Sir John French for Distinguished Conduct.

Charles Cotton, '15, with the Montreal Battery, has received a commission in recognition of his fine work at Langemarck and has been recommended for the D.C.M.

CASUALTIES

Lieut. Fred T. Nicholl, '10, Eleventh Battalion, has been reported wounded.

Pte. F. W. Clark, '12, Fourth Battalion, is wounded.

Sgt. C. B. Ferris, '13, of the 2nd Field Company of Canadian Engineers, wounded at Langemarck. He was the only original sergeant left after this battle.

Lieut. Andrew J. Gray, '13, Sixteenth Battalion, wounded.

Lieut. Ian MacIntosh Sinclair, '17, Thirteenth Battalion, wounded.

Lieut. Angus N. Worthington, '11, Thirteenth Battalion , wounded.

Capt. J. G. Helliwell, '10, First Battalion, wounded.

D. D. James, B.A.Sc., '89, and **O. S. James, B.A.Sc.**, '91, are now residing at 6 Leuty Ave., Toronto.

K. A. Jefferson, B.A.Sc., '15, is with the Canadian Inspection Co. Resides at 40 West Main St. N., Galt.

E. W. Kay, B.A.Sc., '07, now resides at 517 Bannatyne Ave., Winnipeg.

C. R. Keys, B.A.Sc., '15, on mechanical designing for the Curtiss Aeroplane Co., Toronto.

J. Lanning, B.A.Sc., '11, is surveyor and estimator on the construction of the Whitby Hospital for the Insane. His address is Box 673, Whitby, Ont.

R. E. Laidlaw, B.A.Sc., '15, is foreman on Trent Canal for the Interior Construction Co. His address, Burndick, Ont.

R. A. McLellan, B.A.Sc., '11, is resident engineer for Murphy & Underwood, Ross Building, Saskatoon.

F. S. Milligan, B.A.Sc., '10, is with the Railway Department, city of Toronto. Residence, 33 Rathnally Ave., Toronto.

W. MacLachlan, B.A.Sc., '06, with the Electric Power Co., Confederation Life Building, Toronto.

W. R. McCaffrey, B.A.Sc., '15, is in charge of a party on irrigation work for the government in Western Canada.

E. V. McKague, B.A.Sc., '15, is resident engineer on the Rapid Transit Commission, Toronto.

DIRECTORY OF THE ALUMNI

Flynn, C. C., '11, was in Chicago, with the Western Electric Co., Limited, when last heard of.

Follett, R. C., '10, has no address upon our records except his home address, Oakville, Ont.

Foote, F. F., '13, is at Merritton, Ont.

Forbes, D. L. H., '02, is chief construction engineer for the Chile Exploration Co., Chuqicamata, Chile, South America.

Ford, A. L., '04, is government inspector and engineer, Department of Railways and Canals, at Prince Rupert, B.C.

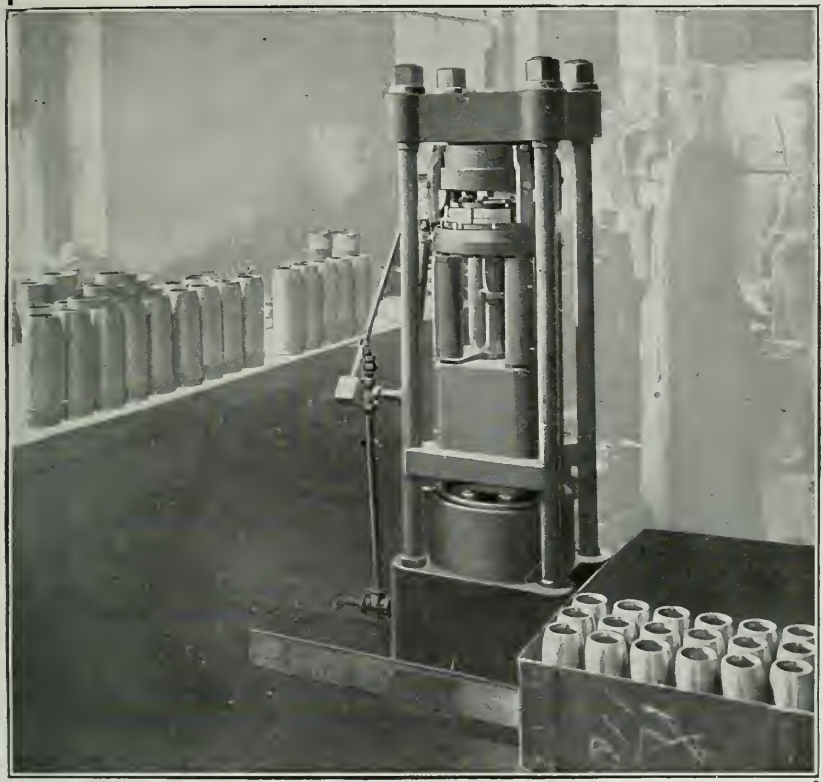
Foreman, J. L., '14. His home is at Collingwood, Ont.

Foreman, J. M., '10, whose home is in Lucan, Ont., has no business address with us.

Forman, W. E., '99, was in Pittsburg with the Westinghouse Electric & Mfg. Co., construction department, when last heard from.

(*Continued on page x*)

BANDING PRESS



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Prices and particulars sent upon request.

Chapman Double Ball Bearing Company
of Canada, Limited

339-351 Sorauren Ave. Toronto, Canada.

Directory of the Alumni

(*Continued from page 82*)

Forrester, C., '93, We do not know his present address.

Forward, E. A., '97, is contractors' engineer with Quinlan & Robertson, Montreal, Que.

Forward, C. C., '06, is analyst in charge at the laboratory of the Inland Revenue Department, 48-50 Bedford Row, Halifax, N.S.

Foster, A. H., '08, is manager of the Guelph Radial Railway Co., and Guelph Waterworks, Guelph Ont.

Foster, W. J., '10. We have no address for him at present except his home address, Windsor, Ont.

Foulds, W. C., '10, is in the Roadways Department, City Hall, Toronto.

Foulds, E. S., '13, is with Field Company No. 2, Canadian Engineers, First Canadian Contingent, Europe.

Francis, Walter J., '93, is the senior member of the consulting engineering firm of Walter J. Francis & Co., Montreal.

Francis, C. C., '08, whose home address is Verschoyle, Ont., has no business address with us.

Frankel, E. L., '11, is manager of Frankel Bros., dealers in metals and millstock, Toronto.

Franklin, H. J., '14, has 270 Robert St., Toronto, as his home address.

Fraser, A., '10, is in the Topographical Surveys Branch, Department of Interior, Ottawa.

Fredin, J., '10, is with the B. C. Copper Co., at Princeton, B.C.

Freeland, E. E., '11, is with the Department of the Interior, Ottawa, in the Topographical Surveys Branch, as assistant topographer.

Freeman, T. E., '09, is in Toronto as sales engineer for the Canadian General Electric Co.

Freeman, J. R., '11, is in the bridge department of the Intercolonial Ry. Co., at Moncton, N.B.

Frid, H. P., '11, is taking a post-graduate course in architecture at the University of Toronto.

Frost, E. R., '09, is in Hamilton, Ont., inspecting shrapnel shells for the Canadian Inspection and Test Laboratories.

Frost, J. G. G., '14, is with the Metals-Chemical Co., Welland, Ont.

Fuce, E. O., '03, is carrying on a consulting engineering practice in Calgary, Alta., in partnership with W. A. Scott, '06.

Fuller, C. H. R., '14, is with the Department of Public Works, on the construction of the Toronto-Hamilton road. He is secretary of the Toronto Branch of the Canadian Society of Civil Engineers.

Fuller, R. J., '11, is in the city architect's department, City Hall, Toronto, as structural engineer.

Fullerton, C. H., '00, is in New Liskeard, Ont., where he has a practice as engineer and surveyor.

Fux, P. C., '07, is advertising manager for the Waterous Engine Works Co., Brantford.

Fyfe, H. D., '11, is engaged in contracting at Vancouver, B.C., His address is 323 16th St. W., North Vancouver, B.C.

G

Gaby, F. A., '03, is chief engineer to the Hydro-Electric Power Commission, with headquarters at Toronto.

Galbraith, J. S., '13, is demonstrator in drawing, Faculty of Applied Science and Engineering, University of Toronto.

Galletly, J. S., '07, whose home is in Brooklin, Ont., was on D. L. S. work in the west, when our last information was received.

Galt, G., '07, is metallurgical engineer for the Braden Copper Co., Rancagua, Chile, S.A.

Gardner, J. C., '03, has a private engineering practice at Niagara Falls, Ont.

Garland, N. L., '90, is engaged in building and contracting in Toronto.

Garrow, A. B., '07, is assistant engineer, main drainage department, City Hall, Toronto.

Gear, S. S., '08, is city engineer of St. Catharines, Ont.

George, R. E., '03, has no address with us.

Gibbons, J., '88, was in Ottawa, Department of the Interior, when last heard from.

Gibson, A. E., '02, is assistant engineer with Roger Miller & Sons, engineers and contractors, Toronto.

Gibson, J. M., '10, is with the street commissioner, Toronto, preparing a report relative to proposed scheme of garbage disposal, etc.

Applied Science

INCORPORATED WITH

TRANSACTIONS OF THE UNIVERSITY OF TORONTO ENGINEERING SOCIETY

Old Series Vol. 27 TORONTO, AUGUST, 1915 New Series Vol. X. No. 4

RADIATOR TRAPS AND TEST DATA

By L. M. Arkley, M.Sc.*

The primary object of a steam trap is to actuate a valve in such a way as to permit all water or condensed steam to flow quietly out of the radiator and at the same time, to allow none of the steam to escape with it. It will be seen that, to keep the radiator well cleared of water, the valve must operate very often. It is therefore subject to more or less wear. In the main, two general principles are employed, namely, the float and the thermostat. In the float type the valve is simply part of a hollow vessel and is lifted and opened by the water collecting under it. When this water runs away the valve, of course, settles to its seat.

The thermostatic valve is actuated by the contraction and expansion of metals or gases due to heat. When the thermostat is surrounded by water, it is naturally cooler than when in contact with steam with the result that the element shortens and opens the valve.

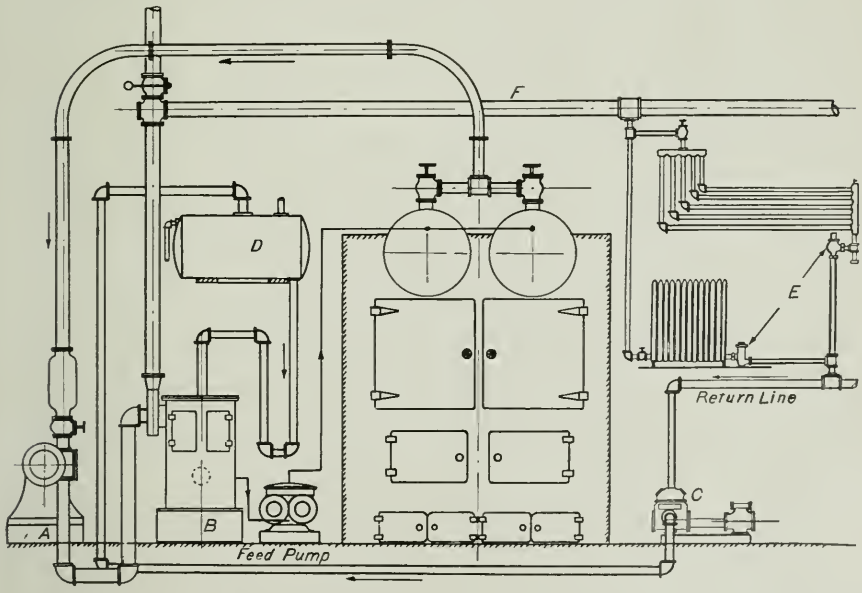


Fig. 1. Outline of Vacuum Heating Plant, Illustrating the use of Radiator Traps

*Lecturer in Mechanical Engineering, University of Toronto.

Fig. 1 illustrates the common method of using radiator traps in connection with a vacuum heating system. Live steam from the boilers is used to drive the engine indicated at A. Exhaust steam from the engine is taken to the feed water heater B where approximately 1-7 of the heat units in it may be used to heat the feed water for the boilers from a temperature of say, 50° to 210° F., and the remaining 6-7 will thus be available for the heating system. This exhaust steam at low pressure is led directly to the radiators, and a vacuum is pumped on the return lines of the system by the vacuum pump C. The pump discharges the condensed steam into the tank D, from which it flows by gravity to the feed water heater B. After being heated to the temperature of 210° or 212° F. in the heater, it completes the circuit by being returned to the boilers by the feed pump.

In a heating system of this kind we might operate the plant with a steam pressure of from 0 to 5 pounds per sq. inch on the pipe F, and with a vacuum of from 8 to 10 inches on the return line, these values of course depending on the number of square feet of heating surface being supplied and the distance the steam has to be carried.

It is clear that under these conditions steam would blow through the radiator without being condensed and giving up its latent heat, unless some provision was made to prevent it. To stop this waste of steam, traps are placed on the return ends of the radiators as shown at E

In order to test the comparative efficiencies of several well-known makes of radiator traps the apparatus shown in Fig. 2 was fitted up in the Thermodynamic Laboratory of the University of Toronto.

Description of Apparatus

The apparatus consists essentially of a standard type of radiator having 60 square feet of radiating surface and which is connected to the steam pipes in the same way as when set up for actual service. A mercury manometer is attached to the inlet pipe to register the pressure of the steam entering the radiator, while a thermometer in the same pipe can be used to indicate the temperature when desired. To the outlet pipe is attached a radiator trap E, a tank B, in which is collected the condensed steam from the radiator, a glass condensing coil, and a glass jar A, which condenses and collects any steam that may pass the trap.

There is an advantage in having the condensing coil and jar A of glass, as, during the test, the rate at which the steam is passing the trap may be noted and the completeness of condensation verified. The desired vacuum was indicated on gauge C, and was obtained by connecting the apparatus to a vacuum pump as shown.

Object of Test

(a)—To determine whether the traps performed their main function, namely, that of allowing all water of condensation to pass from the radiator without letting steam pass as well.

(b)—To determine the temperature efficiency of radiator.

(c)—To determine whether all air was removed from the radiator by the trap.

(d)—To determine whether the traps performed their functions without noise.

Method of Making Tests

Before starting the tests, steam was turned on the radiation and the system allowed to heat up to its normal working condition; after this, readings of temperatures and pressures were taken at intervals of ten minutes for a period of two hours. If any water had collected in the radiator during the test it was drawn off and weighed.

By referring to Fig. 2, it will be seen that tanks A and B are so connected that they are always under the same vacuum of pressure, the water-leg preventing steam from passing to the tank B, therefore, if any steam passes the trap, it will find its way to the condensing coil and from there to the tank A. The weight of water in B represents the steam condensed in the radiator, while the water in A, after the proper correction has been made, represents the steam that has passed the trap.

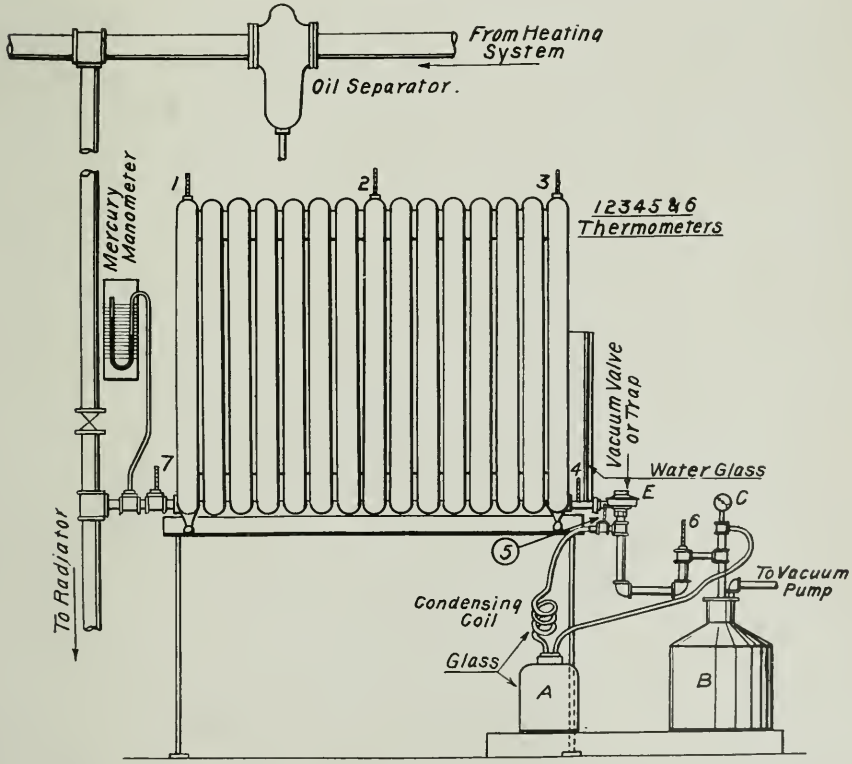


Fig. 2. Arrangement of apparatus as set-up for Testing Radiator Traps

Method of Computing Results

In order to get the true value of the steam passing the trap a correction must be made to the quantity caught in tank A, because a certain amount of the water in the radiator which would remain as water while under the pressure in radiator would burst into steam after passing to the lower pressure beyond the trap. The following method will give a close approximation to what this correction should be.

Let A = the number of pounds of water caught in tank A.

Let B = the number of pounds of water caught in tank B.

Let r = the heat of vaporization of one pound of saturated steam under vacuum.

Let X = temperature of water at thermometer No. 4.

Let Y = temperature of steam corresponding to vacuum.

Let C = correction, i.e., the number of pounds of water to be deducted from A.

Let E = net weight of steam passing trap.

Then $C = \frac{(X-Y)}{r} \times B$ and $E = A - C$.

The above correction, while not exact, is quite close enough for practical purposes, and as it has been applied to each valve tested, the comparison should be fair.

The temperature efficiency of the radiator is defined as the average temperature of the radiator divided by the temperature of saturated steam corresponding to the pressure in the radiator. The temperature efficiency gives a very good indication of the quantity

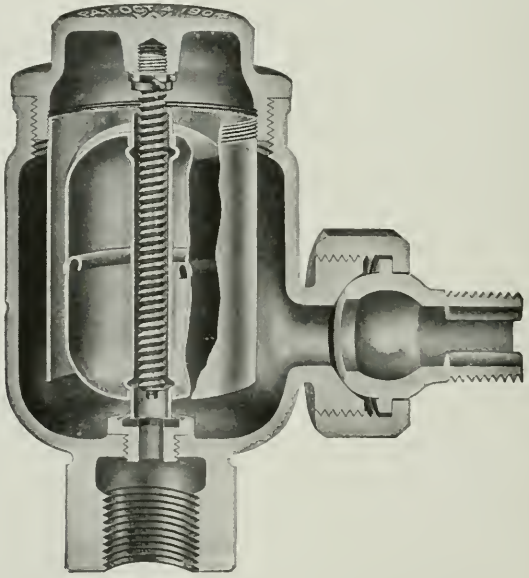


Fig. 3. Webster Water Seal Motor Trap—Float Type

of air being trapped and held in the radiator sections. For instance, if the temperatures as read from thermometers 1, 2 and 3, Fig. 2, are nearly equal, and not far below that corresponding to the steam pressure, it shows that steam is filling each section and therefore air must be absent. In the following tabulation the first test is given complete; in the others, only the minimum, maximum and average values are given for the pressures and temperatures, and the final results. Particulars of the traps tested are as follows:

Webster Water Seal Motor

This trap, Fig. 3, operates on the float principle. As shown in the figure, it consists of a metal shell in which a float fits loosely. The float is made of pressed steel with a hollow tube passing through its centre, a spiral screw fastened to the valve cover serving as a guide for the float. The air discharge is down through the hollow tube in the float which connects directly with the return line. When the water (which will rise higher in the valve than in the radiator due to the vacuum) reaches a certain height, the float rises and allows the water to be discharged.

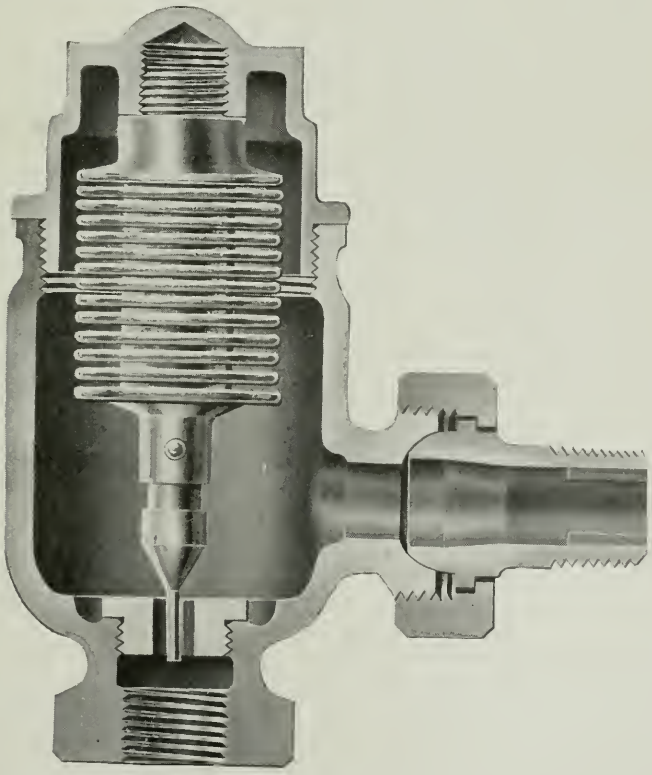


Fig. 4. Webster Sylphon Trap—Thermostatic Type

Webster Sylphon Trap

This trap, shown in Fig. 4, operates on the thermostatic principle. Most traps which depend for their action on this principle, have an expanding member, one end of which is fixed firmly to the cover of the valve chamber, while the other end carries the valve. This expanding member is usually hollow and contains a volatile fluid which readily changes to the form of gas when its temperature is slightly increased. Suppose the valve in the trap closed. Water will begin to accumulate and its temperature will fall slightly. This drop in temperature causes the expanding member to contract which opens the valve to discharge water. As the water flows out, it becomes warmer and this allows the valve to close slightly and reduces the flow.

As shown by the results of these tests, a radiator trap made on this principle may be adjusted to work very satisfactorily. By referring to Fig. 4, it will be seen that the expanding member in the Webster Sylphon Trap is a hollow brass spiral coil one end of which is attached to the cover and the other to the valve stem. The body of the valve is of cast iron and the valve and stem of brass. The valve itself is cone shaped.

D. G. C. Trap

This trap, a section of which is shown in Fig. 5, operates on a different principle from any thus far described. The steam passing through the screen at the right of the figure, reaches the rectangular chamber adjacent. A small, circular opening connects this chamber with the valve chamber directly below, and, through this opening, all water and air must pass.

The valve consists of a small circular disc of brass with a stem

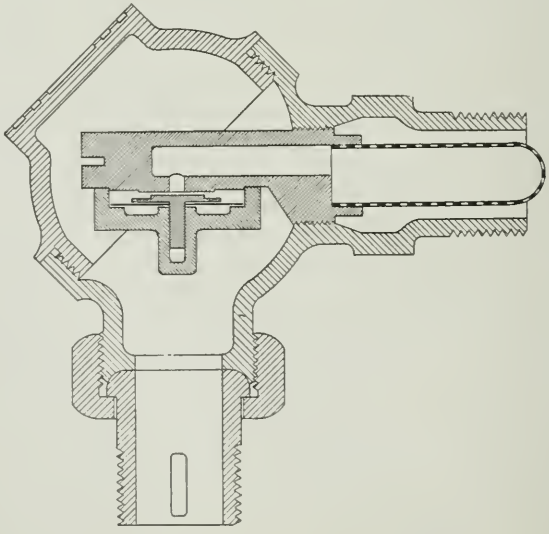


Fig. 5. D.G.C. Trap—Difference in Pressure Type

attached to the under side to act as a guide. If steam passes through this small orifice, its velocity is increased, and this high velocity steam blowing down on top of the valve disc, creates an area of low pressure above it. The disc rises and closes the opening as soon as the pressure under it becomes greater than that above it.

Hains or "Vento" Trap

A cross section of this trap is shown in Fig. 6. The operating member which closes or opens the valve is a U tube which is hollow, and is filled with a volatile fluid. When the pressure in the tube increases, due to the increase in temperature, the prongs of the tube spread and close the valve. When the temperature falls, the prongs come together and thus open the valve. The body of the trap is of cast iron, while the U tube and valve are of brass.

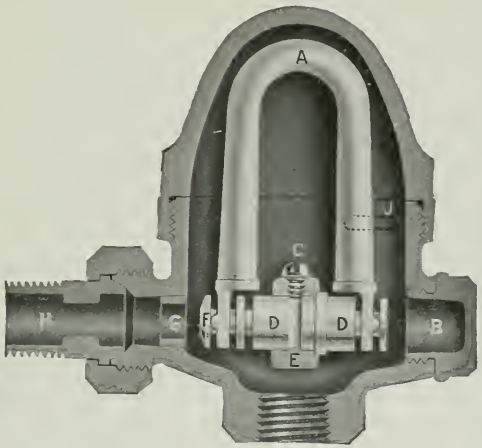


Fig. 6. Hains or "Vento" Trap—Thermostatic Type

"Welo" Radiator Trap

This trap is shown in cross section in Fig. 7. It also operates on the thermostatic principle. The receptacle for the expansive fluid is a corrugated copper tube and, to this tube or cartridge is attached the valve. If steam comes in contact with the corrugated tube, it expands until the valve is closed. When sufficient water has collected to reduce the temperature slightly, the valve opens to discharge the water and air. The corrugated tube is of copper and the rest of the trap is made of seamless bronze.

No. 8 Sarco Steam Trap

By referring to Fig. 8, it will be seen that this trap is in form very much like the "Welo," which has just been described and that it also works on the thermostatic principle. The main difference is that, in this trap, the expansive fluid surrounds the corrugated tube to which the valve is attached and is not within the tube as in the

case of the "Welo." The body of the "Sarco" trap is of steel and the expansion member is made of copper.

"Marsh" Reflux Trap

As seen from Fig. 9, this trap operates on the thermostatic principle, the hollow corrugated disc containing the expansive fluid is inserted between the valve and a hollow stem fixed to the top of the cover. The action is the same as in other types of thermostatic valve described.

"Durham" No. 1 Radiator Trap

From Fig. 10 the method of operation of this trap is clear. The expansion member is a hollow corrugated disc which contains the

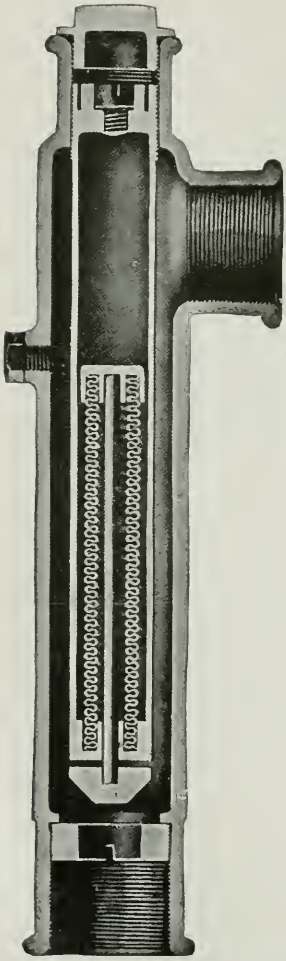


Fig. 8. Sarco Steam Trap—Thermostatic Type

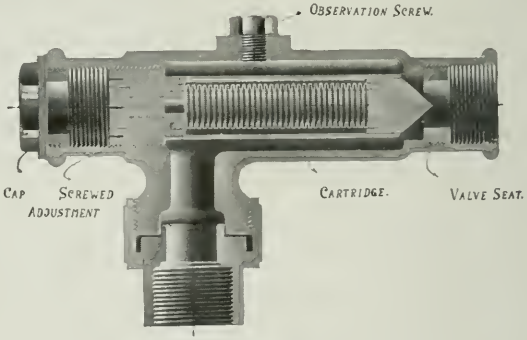


Fig. 7. The "Welo" Radiator Trap —Thermostatic Type

volatile fluid. One side of this disc is fastened to the cover, while the other side carries the valve. A slight variation of temperature inside the trap will cause the valve to open or close. The hollow disc is made of copper and the body of the trap of brass.

Purpose of Tests

These tests were made primarily for the purpose of satisfying the writer as to the value of radiator traps, which he has had occasion to specify at different times in connection with the design of low pressure heating systems. Numerous inquiries along this line from architects and heating engineers would indicate that the question is a live one with all men directly interested, and seems to justify the publication of the results of this somewhat exhaustive test.

It must be remembered that there are other important features

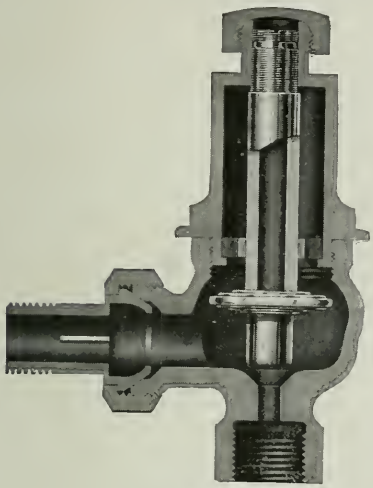


Fig. 9. Marsh Reflex Trap—Thermostatic Type

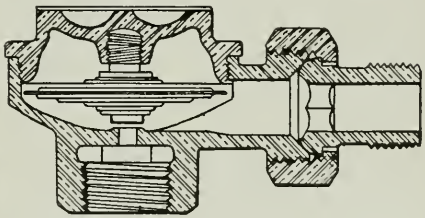


Fig. 10. Dunham No. 1 Radiator Trap—Thermostatic Type

connected with radiator traps which cannot be decided by laboratory tests, for example, mechanical construction on which depends the life of the valve and its seat. The lift of the valve from its seat and the shape of both valve and seat determine its likelihood to clog on account of scale or dirt coming from the radiator. The ease with which the traps may be cleaned and kept in running order is also a very important feature. Mechanical knowledge and good judgment on the part of the purchaser should enable him to choose the best trap from a mechanical standpoint, but the length of life and other such questions can only be determined by comparing the action of traps operating over long periods of time under similar conditions.

The writer wishes to acknowledge suggestions and help given by Professor R. W. Angus, of the Department of Mechanical Engineering of the University of Toronto, and also the hearty co-operation of the manufacturers who furnished the traps tested.

No. of test	Values given	Time	Pressure Inches Mercury	Pressure Inches Vacuum	Temperatures 1	2	3	4	5	6	Room	Name and type of trap	Aver. temp. of radiator	Temp. efficiency of radiator	Steam condensed in radiator	Lbs. of steam passed by trap	% of steam passed by trap
2	Min.	10.11	2.7	9.0	214.0	215.0	213.0	212.0	182.0	180.0	**100.0**	*Webster	.....	.....	.....	.....	.....
	Max.	to	3.8	9.0	216.0	217.0	215.5	215.0	191.0	187.0	**106.0**	Sylphon	.....	.....	.....	.....	.....
	Aver.	12.11	3.05	9.0	215.0	215.6	214.4	213.8	188.5	185.0	**102.0**	Trap	**215.0**	99.1	38.5	0.00	.....
4	Min.	10.40	2.70	9.0	214.0	215.0	214.5	215.0	183.0	190.0	.....	*D. G. C.	.....	.....	.....	.....	.....
	Max.	to	3.10	10.5	215.0	216.0	215.0	216.0	194.0	198.0	.....	Disc	.....	.....	.....	.....	.....
	Aver.	12.40	2.92	9.6	214.6	215.5	215.0	215.7	190.6	194.0	.....	Trap	**215.0**	99.2	43.5	0.54	1.22
5	Min.	20.8	2.70	10.0	213.5	214.5	214.0	214.5	189.0	192.0	**98.0**	*"Vento"	.....	.....	.....	.....	.....
	Max.	to	3.30	10.0	215.0	215.0	215.0	215.0	190.0	193.0	**110.0**	Ther'static	.....	.....	.....	.....	.....
	Aver.	40.8	2.96	10.0	214.0	215.0	214.2	215.2	189.7	192.4	**107.0**	Trap	**214.4**	98.94	46.5	0.58	1.21
6	Min.	15.5	2.10	9.0	213.0	214.0	213.0	212.0	186.0	182.0	**106.0**	*"Welo"	.....	.....	.....	.....	.....
	Max.	to	4.20	10.0	217.0	217.5	217.0	215.0	189.0	183.0	**107.0**	Low press.	.....	.....	.....	.....	.....
	Aver.	3.55	3.03	9.16	214.7	215.4	214.6	212.5	188.5	182.0	**106.7**	Trap	**214.9**	99.1	36.0	0.00	.....
7	Min.	10.29	4.50	8.00	217.0	218.0	216.0	207.0	172.0	173.0	**95.0**	"Sacro"	.....	.....	.....	.....	.....
	Max.	to	4.60	10.00	217.5	218.25	217.0	217.25	194.0	197.0	**101.0**	*.....	.....	.....	.....	.....	.....
	Aver.	12.29	4.54	9.32	217.3	218.10	216.9	214.5	181.0	180.2	**99.0**	.....	**217.4**	99.2	41.0	0.25	0.6
8	Min.	2.25	3.1	7.5	215.0	215.0	214.5	215.0	191.0	183.0	**97.0**	Marsh	.....	.....	.....	.....	.....
	Max.	to	5.6	9.5	219.0	220.0	219.0	219.0	192.0	188.0	**104.0**	*Reflex	.....	.....	.....	.....	.....
	Aver.	4.25	5.08	9.1	218.1	219.1	218.2	217.5	191.8	186.0	**101.4**	.....	**218.5**	99.3	39.5	0.03	.....
9	Min.	10.12	3.9	9.0	217.5	217.0	215.6	216.0	180.0	176.0	**75.0**	*Dunham	.....	.....	.....	.....	.....
	Max.	10.12	4.0	10.5	217.5	217.0	216.0	216.0	184.0	190.0	**79.0**	No. 1 Radiator	.....	.....	.....	.....	.....
	Aver.	10.12	4.0	10.0	217.5	217.0	215.8	216.0	182.0	187.5	**76.0**	Trap	**216.8**	99.2	39.1	0.00	.....

*All the traps tested operated without noise, and none of them allowed air or water to gather in the radiator.

Log Sheet of Complete Data Taken in Leading Test No. 1

Steam pressure

Time p.m.	Inches of mercury	Vacuum inches	Temperatures in Degrees F. 1	2	3	4	5	6
2.48								
2.50	2.2	10.0	214.0	214.5	214.0	214.0	187.0	190.0
3.00	2.2	10.0	214.0	214.5	214.0	214.0	189.0	192.0
3.10	2.2	10.0	214.0	214.5	214.0	214.5	190.0	192.0
3.20	2.1	10.0	213.5	214.5	214.0	215.0	191.0	193.0
3.30	2.1	9.5	213.5	214.5	214.0	214.5	190.0	192.0
3.40	2.1	10.0	213.5	214.5	214.0	214.5	191.0	193.0
3.55	2.1	10.0	213.5	214.5	214.0	214.0	189.0	191.0
4.05	2.1	10.0	214.0	214.5	214.0	214.5	190.0	191.5
4.15	2.4	10.0	214.5	215.0	214.0	215.0	190.0	192.0
4.25	2.5	10.0	214.0	215.0	214.5	215.0	190.0	193.0
4.35	2.5	10.0	214.0	215.0	214.5	215.0	190.5	193.0
4.45	2.5	9.5	214.0	215.0	214.5	215.0	191.0	193.0
4.48	2.5	10.0	214.0	215.0	214.5	215.0	191.0	193.0
Average values	2.27	9.9	213.9	214.6	214.1	214.6	190.0	192.0

Total period of test = 2 hours.

Average temperature of radiator..... = 214.2

Temperature corresponding to pressure in radiator..... = 215.6

Temperature efficiency of radiator..... = 99.3

Name of Trap.....Webster Water seal motor.

Steam condensed in radiator..... = 38.5 lbs.

Steam passed by trap..... = 0.61 lbs. = 1.58%

No air or water collected in radiator.

Operation of trap noiseless.

EDITOR :—It might be well to point out, that in comparing the various foregoing traps on the basis of the results of this experiment shown on page 92, their efficiency and the amount of water condensed is a function of the room and radiator temperatures. Therefore to get an accurate conception of each trap, the result as set out in the four columns to the right, should be modified by consulting the corresponding room and radiator temperature.

J. T. Mogan, B.A.Sc., '15, is on the Toronto Harbor Commission work.

J. M. Muir, B.A.Sc., '15, is with the department of education, Toronto.

Prof. C. R. Young, '03, and **H. H. Madill,** '11, have taken their captaincy papers at Niagara.

Wm. A. O'Flynn, B.A.Sc., '11, has accepted a position as 2nd chemist for the Mond Nickel Co., Coniston, Ont.

H. M. Peck, B.A.Sc., '15, is on geological survey work along east coast of James Bay.

H. A. Ricker, B.A.Sc., '08. Residence, 93 Sanford Ave. S., Hamilton.

C. C. Rance, B.A.Sc., '15, is with Canadian Inspection Co., Toronto.

A. A. Richardson, B.A.Sc., '15, is with the city engineer of Peterboro.

A. C. Ross, B.A.Sc., '15, is with the Canadian Inspection Co., Toronto.

M. L. Smith, B.A.Sc., '11, formerly associate editor for MacLean Publishing Co., Toronto, has accepted the position in charge of engineering at the New Technical School, Toronto.

MINOR DETAILS IN THE ENGINEER'S CAREER

By J. H. Kennedy, C.E., O.L.S., '82

In selecting this subject for a few remarks the author has endeavored to recall the time when he left the halls of the old School, and consider what he now believes after years of experience would have been most useful to him at that time; and it has occurred to him that a few rambling remarks along the line of posting the students and young graduates upon the snags they are liable to encounter, would be a fitting subject for one, who, if not the first graduate of the old School, believes himself to be the first to reach the chloroforming age in active work. The details proposed to be discussed are not called minor because they are of little importance, but because they are unseen when leaving school and their presence unknown until they become snags to progress. The young graduate looking through his mental telescope sees himself about to cut a wide swath with a clear blue sky line, through the world up the hill of fame, and it may be fortune, with the expectation of reaching heights and depths as yet unexplored. This is perfectly right and proper, and no fault is to be found with it. May it ever be so. Engineers must be men, of broad vision and optimistic, if they are to succeed. However, the time will come to each when he will reverse his mental telescope and view as a back sight what he had so fondly looked forward to as a foresight. The present paper is an attempt to point out a few of the minor obstructions to view while they are still foresights so they may not obstruct the backsight along the narrow and crooked traverse line that so many of us follow. If successful it will be of more real value to those for whom it is written than anything that can be said along the line of description of actual construction as followed by the usual methods, so well known to the profession. Now the first jolt the young graduate receives is when he realizes that the world instead of anxiously waiting for him to emerge from the college with the latest ideas and abstruse mathematical formulae will have nothing to do with him, except as a subordinate, because he has no practical experience in actual work. So he learns for the first time that the industrial world is very slow to give him credit for knowing how to do anything until after he has done it.

He learns that no capitalist will furnish the funds for any purely theoretical man without practical experience, to experiment with; so the only possible opening for him may be a position as rodman or instrument man. This instead of being a hardship will be a great benefit to him as it will give him an opportunity not only to see work in progress, but to learn ways and means, cause and effect; also an acquaintance with the men associated with actual work, and their methods of conducting work. He should learn from his own and other mistakes as well as from their successes. While thus employed his field notes will need considerable attention. Here is where many otherwise good men fall down. It is a notorious fact that the average instrument man that applies for such work today

is a nuisance to all concerned. Not only does he keep incomplete notes; but he fails to date, sign, or index his book, or record what his notes refer to, in such a way that his book will be understood by his successor. Such notes may not lead to discharge, but are most certain to prevent re-employment. For the above reason every young engineer should paste this in his hat. No railway or other company will keep a man on its engineering staff as an expert to explain his own notes; and his field notes may be his best recommend or his condemnation, whether he knows it or not. Field notes have turned down many otherwise good men in the past and will continue to do so in the future, notwithstanding all that can be said along this line.

Those of your readers who have had the good fortune to pass their college course under the tuition of our late Dean Galbraith, will recollect that he always urged his class to form the habit of keeping a diary for reference, for details of every day occurrences, sketches, etc. The author has kept such a diary since the spring of 1882 and would heartliy recommend it to all. One cannot remember details. Memory is treacherous, besides you may be a witness at some time when your diary will be better than the other man's memory. Some years ago Smith and Jones, two college graduates, but not of the old S.P.S., and that wasn't their names, were placed upon adjoining sections of railway grade, as assistant engineers. Their work was separated by a stream over which was to be erected an important bridge. After the grading work was well along and the bridge was to be staked out and superintended, it was decided to give the work to Smith as the better man. In fact Jones was not considered a safe man to depend upon. Though Smith could quite easily have taken this work along with his present work he refused on the ground that he already had more and more difficult work than Jones and as Jones received the same salary he considered it unfair to him. The consequence was that a new man Brown was employed for the bridge work; and as Brown proved a good man, he was retained and given what remained of Smith's and Jones' work, when it became necessary to reduce the staff. Now Smith's mistake was that he did not see that Jones' unfitness was his opportunity. Though they received the same salary he was forging ahead, while Jones' slipshod work was finding him out. Through his fear that he might be called upon to do something for nothing, Smith lost his best opportunity for advancement. His superior officer was the best judge as to whether he could handle the work and the fact that it was offered to him was evidence that his worth was appreciated, as well as to the fact that he was not overworked. Young man do not fail to recognize that after you have worked for a time upon the engineering staff of any corporation, your whole stock in trade, outside the few dollars you have earned, may be bound up in the estimate your superior officer has formed of your worth, and others know or care very little about you. Now that opinion is not necessarily formed by your scholarship alone it is just as much your accuracy in details, your industry, reliability and general make up. It is his recommend

that helps you to a higher position in at least nine cases out of ten; and the tenth comes to you because it is known that you have been in his employment. The fact that Jones received the same salary as Smith was no argument for Smith, as he received no less on that account. For illustration we may take another case in which Mr. Jones is an assistant engineer with a good C. P. Ry. record behind him and Smith a recent graduate of an Eastern college, is sent to him as rodman or instrument man, upon rough sidehill work. After a short time together in which they did not agree very well, Smith left his work and came to the writer with a tale of woe in which he claimed that Mr. Jones did not understand how to stake or calculate his work; and moreover Mr. Jones had left his work in his, Smith's charge, for some time and gone out on other business, so he was afraid he was doing all the work and Mr. Jones would get all the credit for it. Now where was this man to get the credit from if not from Mr. Jones himself. His eyes had not been opened to the fact that the niceties of the higher mathematics when applied to the necessarily rough work on the mountain side become absurdities. No college training in the higher mathematics will compensate for a lack of common horse sense. Leaving out of consideration the over estimate of his own importance, which Smith will soon outgrow, he was not loyal to Mr. Jones as he should have been. The soreheads of the engineering profession today are largely those who believe they have done the work of their superior officers or have furnished the brains and their abilities have not been recognized by the powers that be. This will always be the case for obvious reasons. It is not here argued that employers and Chief Engineers are always above criticism, being human like other people. Nor is it to be understood that the young graduate is in duty bound to take what he gets and be thankful that he gets anything whether it be much or little. What is claimed however, is that the salary received when making a start in the engineering world should not loom up to unduly large proportions to obscure other advantages in the way of receiving practical experience. It is experience that counts in the employer's opinion and your college training gives the power to turn that experience to your best advantage. May it aid you through the crowded ranks to a place at the top where there is said to be plenty of room.

MERCURY

In these days of experiment, most mechanical men have more or less to do with mercury. Being an elementary substance, it might be supposed that the nature of the metal would prevent it from being adulterated. However, this is not the case.

Mercury is an expensive substance and is frequently adulterated with lead, tin and other inexpensive metals that can readily be dissolved in it without very greatly affecting its fluidity. Such manipulations spoil mercury for experimental purposes and it is well to make a simple test for detecting any foreign matter. Put a drop of the metal on a plate of glass and roll it around. Pure mercury leaves no trace and rolls in spherical globules, while the adulterated mercury forms elongated tears covered with a gray pellicle which adheres to the surface.

NEW TYGARD ENGINES FOR IMPROVING SUBMARINE SERVICE

James W. Tygard

The Secretary of the United States Navy, Josephus Daniels, is making every effort to increase the efficiency of the submarine, and the Tygard Engine presents a new plan by which the great difficulties, due to the impure air discharged from the storage batteries, used in propelling the submarine when submerged, are removed.

Present System

In the present system while the submarine is not submerged, Deisel engines are used to compress air for the use of the crew and for the propulsion of the torpedoes from the tubes of the submarine.

The Deisel engines also generate electricity which is stored in a heavy and bulky system of batteries; the electricity being used later when the boat is submerged to drive its propelling screw by means of an electric motor.

This present method is a heavy, cumbersome, power-wasting system, and has the very great disadvantage of having the air, which the crew is forced to breathe, contaminated with the noxious gases that are continuously discharged while the storage batteries are in operation.

New Method

By the new system, the Tygard double-acting oil engine is used to compress air under high pressure in a system of steel bottles or reservoirs, which occupy some of the space formerly occupied by the storage batteries that are now rendered unnecessary.

The electric generator for driving the screw is totally eliminated; the compressed air being led from the bottles to the reversing type of rotary air engine.

The compressed air after performing its work of propelling the submarine, is exhausted from the engine direct into the body of the vessel, where it adds its supply of pure air necessary to sustain the life of the crew while the submarine is travelling submerged.

Hence, the longer the submarine travels submerged, the more fresh air is supplied to the crew by the vessel's engines for breathing purposes.

The rotary air engine is connected direct to the screw propeller. The oil engine is geared to propeller shaft by the Tygard variable diameter wheel drive giving variable speed and cut-out without clutch.

When air pressure becomes oppressive the oil engine is started, burning up the excess air pressure and exhausting overboard.

Air engine can be used for reversing and manouvering, and starting oil engine.

Double power may be obtained for emergencies by using compressed air in the rotary engine.

Electricity for lighting and heating can be obtained from

electric generator direct connected to small auxiliary rotary air engine.

Increased Efficiency

Reduction in engine weight rendered possible by the new type of Tygard double-acting oil engine and the substitution of the Tygard rotary engine for the electric dynamo, and its attendant batteries, will more than double the amount of mileage possible from a given weight or size of vessel, thus immensely increasing its efficiency.

This new plan will allow the submarine to accompany the fleet to any destination as part of same and permit the flotilla to operate with the same freedom of the fleet, without the limitations under the present system of a "base" of operations.

All existing submarines can easily be changed over to the new system without any extensive alterations of the boat's structure.

Life and Death

The fact that this system permits the storage of at least one hundred times more air under compression for the use of the crew renders less possible the regrettable and fatal disasters which have so often overtaken submarine boats that fail to come to the surface when they wish.

PERSONALS

W. H. Stevenson, B.A.Sc., '01, is secretary of the Power Plant Specialty Co., Monadnock Block, Chicago.

C. P. Sills, B.A.Sc., '11, is now at Seaforth, Ont.

E. H. Scott, B.A.Sc., '15, is guiding tourists throughout northern Ontario for the summer.

R. G. Scott, B.A.Sc., '15, is on geological survey work around Revelstoke.

J. B. Stitt, B.A.Sc., '15, is with the Braden Copper Co., Rancagua, Chile, South America.

J. E. C. Stroud, B.A.Sc., '15, is assistant chemist on smelter at Anyox, B.C.

O. T. G. Williamson, B.A.Sc., '09, resides at 1345 North Shore Ave., Chicago, Ill.

F. H. Wrong, '11, resides at 355 Bedford St., Sandwich, Ont.

J. A. Whelihan, '03, is ranching somewhere in the west. Try Box 165, Regina, Sask.

H. A. Wood, B.A.Sc., '15, is in charge of surveys for the Eastern Division of Toronto Harbor.

H. H. Brown, B.A.Sc., '14, in June last met with a very serious accident at the Lackawanna Steel Co.'s plant at Lackawanna, N.Y., in which his leg was broken and his hips broken and dislocated. He will be unable to engage in his profession for about another six months.

W. M. Brodie, B.A.Sc., '95, is with the Sterling Coal Company, Ltd., 95 Bay St., Toronto.

R. H. H. Blackwell, '10, B.A.Sc., '15, is with the Canadian Inspection Co., Toronto. His address is 32 Wilton Crescent, Toronto.

W. J. Blair, B.A.Sc., '02, is living in Calgary with large farming interests in Alberta.

E. W. Berry, D.L.S., '10, is on D.L.S. work. His home is at Seaforth, Ont.

L. R. Brown, B.A.Sc., '15, his address is 229 Albert St., Sault Ste. Marie, Ont.

W. H. Bonus, B.A.Sc., '15, is with the Canadian Inspection Co., address care of Empire Mfg. Co., London.

VALUE OF ECONOMICS AND BUSINESS TRAINING TO THE ENGINEER

By Eugene W. Stern, '84, M. Am. Soc. C.E.

It has become more and more evident that the engineer is occupying a continually stronger position in the industrial and business world of to-day. Not only as one who is responsible for the design and supervision and the execution of work of a constructive nature, but also as a manufacturer, manager or partner in important organizations.

There are but few large constructing or manufacturing concerns in this country, in which somewhere near the top there is not a highly competent, technically trained man. In New York city, for instance, practically all of the engineering contractors engaged on the more important work, such as the subways, the Catskill water supply system, or the Barge Canal work, have engineer members of the firm as partners.

A generation ago this was not the case. The engineer's field was not nearly so broad. His activities were confined to railroad or municipal work almost entirely. The manufacturer hardly knew him. Andrew Carnegie was one of the first of them to make use of his services and he has most generously and frequently testified to the invaluable services rendered to him by the engineering profession. Those of his competitors who did not follow his lead in this direction were driven out of business.

I believe I am not exaggerating when I say that those corporations who do not to-day show full appreciation of the engineer's work are in a state of decline.

This widening of the field has brought with it, of course, larger responsibility and the necessity for a somewhat different and broader kind of training than what would have been sufficient in the past.

Nowadays the consulting engineer must often advise financial corporations as to many things involving a broad knowledge of economics and finance. For instance, he may have to pass upon the desirability of the construction or purchase of railroads, mines, manufacturing and power plants. He would be very much handicapped were he not to understand a great many of the things which the business man, lawyer and man of affairs concern themselves with, as he has to deal with these men and look at things from their view point. He should, therefore, have a well rounded training, his equipment comprising not only his mathematics, his mechanics, his field and shop practice, but also the training to enable him to deal with the larger affairs in which a knowledge of economics and of course some business training is essential.

The engineer, contractor, or manager, must not only be thoroughly capable in methods of construction and the details of economically handling materials, but must also understand how to handle labor and be thoroughly familiar with business and financial principles and methods.

The things which I have outlined above as being to-day in the proper sphere of the engineer's work, require a broad foundation which must be acquired sometime in his career, if he is to meet his responsibilities.

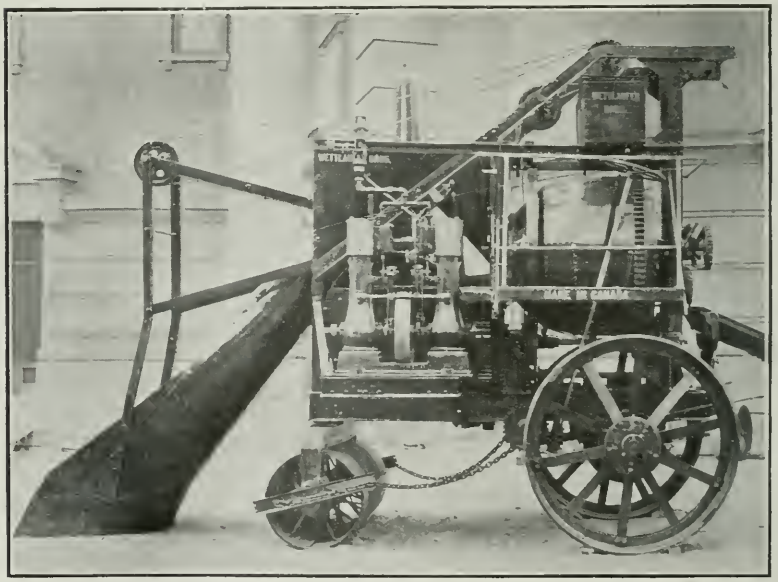
Economics, I believe, should be taught at college, as it is more or less an abstract study and its principles are readily elucidated in the lecture room.

The essential business training, however, should be acquired as an employee in the actual work, for the reason that it is much easier and quicker to obtain the right kind of business knowledge and the practical experience which goes with it, in this way.

COMBINED MIXER AND ROAD ROLLER

Every contractor has hitherto found it necessary to own at least two big machines—a concrete mixer and a road roller—in order to build concrete roads or roads with a concrete foundation. Wettlaufer Bros., Toronto, now claim that a contractor need invest in but one machine, which will take the place, they say, of both mixer and roller.

They have just placed on the market almost ingenious and unique machine—a combined concrete mixer and steam-driven



road roller. The machine weighs 24,000 pounds with roller wheels; 15,000 pounds with small wheels. The entire machine is controlled by one man from one platform, all levers being within reach. He

is not required to leave the operating platform excepting to stoke the fire occasionally.

The machine is capable of rolling at a speed of 9,284 feet per hour. The power is developed from a dry back horizontal boiler of 16-18 h.p. (at 125 pounds steam), by means of a pair of 5 x 5 twin engines, with a speed of 300 r.p.m. The machine has two speeds forward, and is reversible at each speed. The power is transmitted through cast steel gears. The power transmission is sturdily built, and this, in fact, can be said of the whole machine.

The rear roller wheels are each 60 in. diameter by 17 in. face. The front roller is 34 in. diameter by 5 ft. 9½ in. face, and is constructed as four separate wheels. Smaller wheels are also supplied with the machine to be used as desired. The over-all height of the machine is about 10 ft.; height, 12 ft. 6 in., with roller wheels; rolling width approximately 9 ft.

Forming a compact and integral part of the roller, there is mounted a heart-shaped concrete mixer, which has a capacity of 14 to 16 cu. ft. per batch, with a drum speed of 16 r.p.m. The drum is 48 in. diam. x 44 in. in length. The hopper speed is from 8 to 15 seconds. There is a boom delivery of any length desired, but the drum is built high enough to permit a gravity chute to be used to any part of the roadway. The centre of the discharge end of the drum is 6 ft. 9 in. above the ground.

The machine is not being marketed as an asphalt roller, but is primarily intended to enable the contractor to roll the subgrade at night and then to mix concrete during the day, all with the same machine. Whether or not the idea of combining a mixer with a roller proves to be practical and economical, the machine is certainly a new idea and interesting, and it will find a place in paving history.

BUFFALO EXTENSION AND RECLAMATION

By T. Kennard Thomson, D.Sc., S.P.S., '86, M. Am. Soc. C.E.

The very name of the city is a misnomer, as there is no record of bisons ever being at this site, unless, possibly, an odd one or so in captivity.

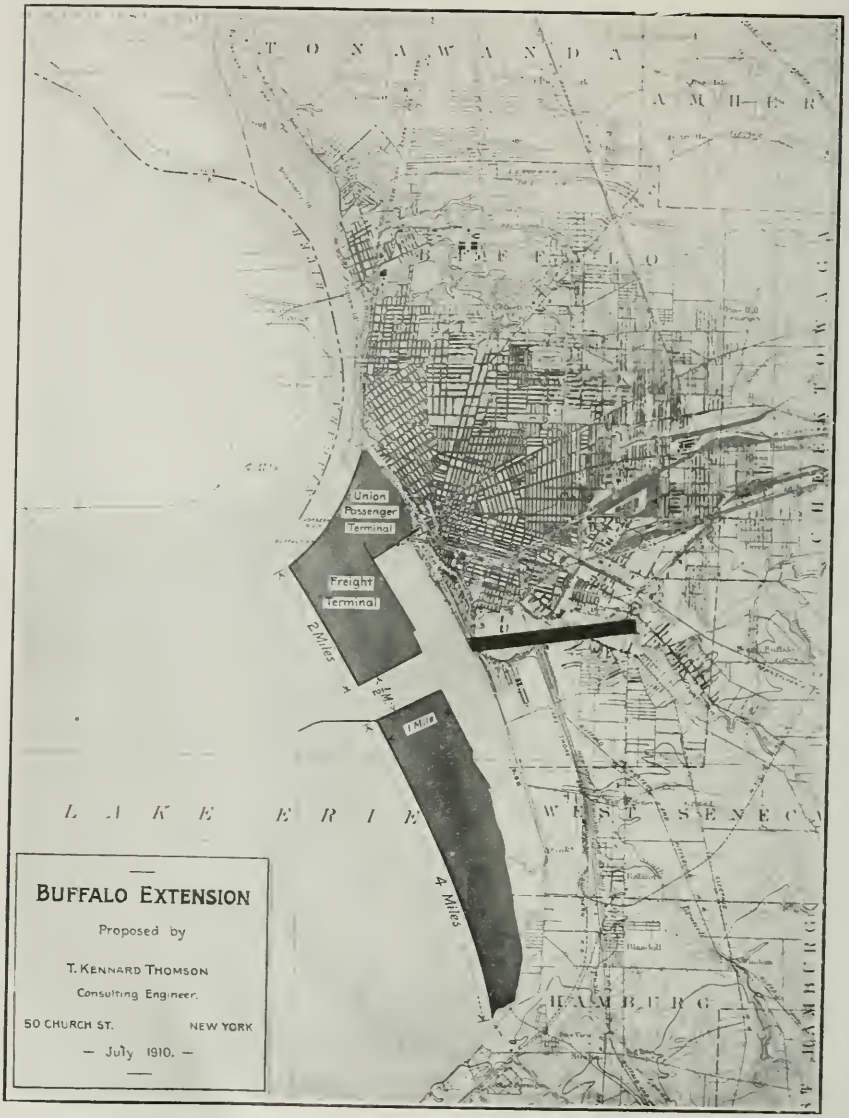
As the ultimate destiny will be a single city from Lake Erie to the Lewiston Escarpment and then, probably, on to Lake Ontario, the question of the future name of the city will have to be settled. And many wonder whether the people of Buffalo or Niagara Falls will insist upon keeping their own name.

Many prominent Buffalonians have told me that there is no justification for the name Buffalo and that, therefore, the future combined city of Buffalo, Tonawanda, La Salle, Niagara Falls and all the other intermediate towns will be, perforce, Niagara Falls.

Like all other American cities, Buffalo has made great strides, partly due to General Greene and his associates, who introduced asphalt streets so extensively into the city many years ago.

The result now is almost a solid city from Niagara Falls to Lake Erie, but under many names and governments.

It might be stated here that one of the first important highways to be built in this country was the Military Road, of about eight


T O N A W A N D A
A M H E R S T
B U F F A L O
Union Passenger Terminal
Freight Terminal
2 Miles
1 Mile
1 Mile
4 Miles
L A K E E R I E
W E S T S E N E C A
H A M B U R G
BUFFALO EXTENSION
Proposed by
T. KENNARD THOMSON
Consulting Engineer.
50 CHURCH ST. NEW YORK
— July 1910. —

miles in length, in almost a straight line from the Lewiston Escarpment to La Salle, on the Niagara River above the Falls. This diagonal short cut saved the roundabout trip by the banks of the

River and the Falls, and was built, of course, to shorten the haul of merchandise from Lake Ontario to Lake Erie—the boats being unloaded at Lewiston and the material reloaded on other boats at La Salle. Even boats were taken up in sections, put together and launched at La Salle. All kinds of furs, etc., were brought back over the same route.

After having enjoyed a period of growth and prosperity Buffalo is suffering from the lack of new enterprise, as no prosperity will continue of its own accord, and unless new ideas and new energy are put forward and pushed to completion, stagnation ensues.

Buffalonians all know that they have reached a period of serious depression, but they have not yet realized how to overcome it—and yet the remedy is perfectly obvious and ridiculously simple, when once realized, as I have pointed out to some of the members of the Chamber of Commerce and others.

Incidentally, I might remark, that in December, 1902, I submitted a plan to Mr. Rust, then city engineer of Toronto, and to others, for the improvement of the Toronto harbor—a plan which was considered at that time entirely too visionary and expensive, but which is now being carried out by the Harbor Board, and promises to make Toronto one of the leading and most up-to-date harbors on the lakes.

The plan which I have submitted to Buffalo and by which I expect to make Buffalo the greatest city on Lake Erie, consists of making a new and safe harbor on an extensive scale—which will not only pay for itself but will also supply money for other developments.

Briefly my project is:—

1st. To construct a breakwater or retaining wall from, at, or near Porter avenue, for a length of about two miles, or out to the present Government breakwater, and then continuing it for one mile beyond—a total curved length of about three miles. See plan.

2nd. To construct another retaining wall or breakwater from near the "Terrace" out to the present Government breakwater.

3rd. To construct two parallel (half a mile apart) breakwater or sea walls, from the Government breakwater, for a distance of one mile, into the lake.

4th. Cut a channel through the existing breakwater between these two parallel retaining walls.

5th. Fill in or reclaim the areas bounded by these breakwaters. See shaded portion on the plan.

These areas as shown cover about seven square miles and can be added to, to an unlimited extent, as required.

6th. Make a new Buffalo River from 500 to 1,000 feet wide, thus reclaiming and making valuable much land that is now spoiled by the winding, shallow river, railroads, etc.

7th. Build a real union passenger station, which will also have access to the lake, where the passengers from lake steamers can step directly into the trains.

8th. Construct a union freight terminal, where all the railroads

can transfer merchandise to and from each other, and to and from the lake and canal boats.

The railroad tracks should pass under the city of Buffalo by means of tunnels or subways, releasing enough real estate—now owned by the railroads—to far more than pay them for the expense of the great improvement.

9th. Utilize the balance of the reclaimed land for summer resorts and cottages on the lake front, and for manufacturing concerns behind.

The walls around the union passenger station should form an enclosed space and be carried down to bed rock, which would be found to be from twelve to twenty feet from the surface of the water. The enclosed space will then be pumped out and be ready for the foundations for the buildings, tracks, etc.

By building jetties, etc., much of the remaining portion would, in time, be filled up by the sand which comes down the lake, especially during storms, when the wind is in the right direction.

As soon as this work starts there will be railroad tunnels from the Canadian side of the river to this new land.

Another advantage will be a real terminal for the Barge Canal, for transfer to the railroads or lake boats, which will be perfectly safe and of ample dimensions.

Some people fear that the addition of new land will lower the values of the old, which is absurd. In the first place, the new land will only be added as required or paid for—in fact, after obtaining the rights to go ahead, and laying the work out on paper, enough land can be sold to start the work, and to keep the work going on; so this is not a serious engineering nor even financial problem, but simply one of education.

Cleveland and other ports will soon leave Buffalo behind if Buffalo does not soon wake up.

The fine boulevards from the parks, with which Buffalo is so well equipped, should be continued so as to pass by the proposed union passenger station, and on through the new land, using tunnels under the channel.

The new city, or rather extension of the City of Buffalo (or Greater City of Niagara Falls), which will be created by this undertaking, **should have all the space—for a depth of one floor—below the street level, kept free, so that it will never be necessary to tear up the street surface to lay pipes, sewers, subways, etc.,—in short a model city should be laid out from the start.**

The lake shore on the new land should be kept for cottages on one side of the boulevard, and bathing beaches on the other side; and this can be gradually pushed out into the lake as the manufacturers require more room. In addition to manufacturing concerns of all kinds, which will be accommodated here, ample room will be provided for coaling stations, lumber yards, grain elevators, dry docks, ship building yards, automobile works, submarines, aeroplanes, etc.

With unlimited cheap electric power, good money and labor markets at hand, and this work started—can anyone imagine stagnation in Buffalo for many decades to come?

LETTERS FROM GRADUATES

Can a Duck Swim?

Dear Mr. Editor,—On page 51 of your June-July issue, "A Graduate" asks if there is a "School" spirit after graduation? In reply I ask another question which it seems to me is just as serious: Can a duck swim? Anyway, the answer to both questions is the same.

The measure of the strength of the "School" spirit is another matter. My experience of twenty-odd years since graduation has taught me that the "School" spirit is stronger than the tie that exists amongst graduates of many other universities. I submit, however, that it is not so strong as it ought to be.

In case "A Graduate" has not met this spirit since he left, I would say that it manifests itself by arousing interest when one School man meets another, by pleasant reminiscences of the four School years, by a desire to join with other School men on occasions, by an interest in the perusal of APPLIED SCIENCE, by a desire to know what is happening in School affairs, by the satisfaction of reading of School successes, by the pride that arises when another School man comes to the top, and by the thrill set up at the sound of the joyous Toike Oike! Toike Oike!

Should there be a "School" spirit after graduation? Undoubtedly there should.

And in reply to the last question, "Of what use is it?" One is tempted to throw up his hands and reply "What's the Use?" In my opinion the usefulness of the School spirit is beyond estimation. I have already suggested usefulness in discussing the manifestations. Let me go on. If the school spirit were properly cultivated, every graduate would subscribe for APPLIED SCIENCE and pay for it, thus making our College paper financially independent, instead of face to face with indebtedness. (School men don't appreciate APPLIED SCIENCE enough, not realizing that it is a most creditable periodical. I am proud of having a complete set from 1885 to date). If the proper School spirit existed there would be a closer bond of union between the faculty and the graduates than that which now exists. If there were true School spirit more of the School men would have better positions than they hold, even if no other principle applied than that of giving a fellow-graduate the preference, other things being equal. And I cannot help feeling that a really true School spirit would lead more of our graduates to take an interest in the great professional societies, for by so doing they would help to elevate themselves, assist in raising the standard of the profession and at the same time place the School in the high place that it deserves.

"A Graduate" who is glad to sign himself,

WALTER J. FRANCIS.

INCREASED PRODUCTION IN CANADA

By Wm. Batten McPherson, B.A.Sc., '11

Many Canadian manufacturers have suffered greatly from the effects of the war. There has been a great dropping off in agricultural implements, steel rails and most other steel products except wire and in various materials used in building and construction. War conditions explain the increases that have accumulated and wheat and foodstuffs as much as cartridges and shells largely explain the situation. France and England are taking enormous quantities of wheat and will continue to do so.

Canada has sent little ammunition to Europe as yet but by October and November Canadian munitions will commence to play a part in deciding the issue, for according to the experts, not the soldiers in the trenches but workmen in the factories, are now carrying on the war. The Allies have a stupendous task clearing the Germans out of Belgium, France, and parts of Russia. The war will probably not be decided until this is done. Military men scout the suggestion that this is an impossible task. Modern engineering can blast its way through mountains of rock; similarly it can blast its way through human impediments in Belgium and France. And in all its hideousness, that is the aspect this twentieth century military situation presents.

No forces, even that of human beings, can withstand the shock of lyddite and melinite. It is only a question of hurling enough at the obstruction. Shrapnel shells exploding in a fan-like mass of bullets over the trenches, produce little more permanent effect than the sprinkling of toilet water; they kill men indeed but the great defences, the trenches are still there, and there are apparently new victims enough to fill the vacant places. But huge charges of high explosives, falling in or near the trenches, simply tear them to bits; concrete, earth and fragments of human beings mingle together in one horrible destruction.

If the Allies can do on an enormous scale, what the English did at Neuve Chapelle and the French at Souchez, they can literally blow the Germans across the Rhine. If the Germans can utilize the same methods against the Allies they can win the war. The issue depends upon which side can use lyddite to the greatest effect. This in turn, hangs upon which side can get the largest quantities.

The countries that send to their armies at the front the largest quantities of explosive shells will probably win this war.

Germany and Austria depend only on themselves. The Allies depend on the remainder of the world. Canada must take her place. The enemy has prepared large quantities of munitions in anticipation of this war, they have been exploding it at a prodigal rate in the past year. When they have exhausted these supplies what are their facilities for further manufacture? How extensive is their access to raw materials? By occupying Belgium, Northern France and Luxembourg, they have acquired territories rich in metal mines which will strengthen their resources. But the position of the

Allies is stronger. England and France can lay the whole world under tribute. Both countries had small reserves of munitions when the war began. But so long as they can hold their present position, they can beat time until they have organized a great and steady supply. They can draw raw materials from a dozen sources in other countries. Canada must be included. We require to work our factories as well as recruiting stations. With England, France, Russia and Italy enlisting the world's mining and manufacturing resources and Germany and Austria depending on themselves, the great military superiority of the Allies becomes apparent. Every man in the field requires at least one man in the workshop. Germany and Austria have to keep millions of their finest men in the factories—men who would otherwise go to the front. But the Allies can enlist huge armies of workmen, the world over—men who are really fighting their battles as immediately as though they were stationed in the trenches.

The newspapers describing great war orders received by American manufacturers, and the extensions which these same concerns are making to their plants give some idea of this new industry. We believed that the production of ammunition was a specialized industry; that only factories constructed for that purpose could do it. But practically any factory that has a lathe can turn out shells. A list of sub contracts let by the Canadian Car and Foundry Company in the United States illustrates this point. Manufacturers of hardware, automobiles, recording and computing machines, drop forgings, locomotives, farm implements, bicycles, screws, steel cars and a dozen other products are now turning their energies to producing shells. Canadian industries are receiving orders but more of our manufacturers can adapt their plants to obtain their share of business and to do their part. Concerns that have been making shrapnel can make explosive shells also; indeed these are less complicated and easier to make than shrapnel, and when our factories can add hundreds of these shells a week to the output of the Allies the situation on the battlefields will gradually change.

Amongst the effects of the war on Canada are the improved understanding and the friendlier feeling between the industrial east and the agricultural west. The common interest involved in increased production has brought the grain grower of the prairie provinces into a harmonious relation with the manufacturer of the east. It is freely recognized that the present world struggle is one of resources and that the supreme duty of Canadian citizens at this time lies in the utilization to the utmost of the bountiful resources with which we have been blessed.

A substantial increase in Canadian production on a sound economic basis is an essential step at the present stage of this country's development. A campaign has been launched to encourage and stimulate larger production in all parts of Canada. The importance of raising larger quantities of meat supplies has been particularly emphasized. The live stock industry has not kept pace with agriculture and manufacturing. During the past twelve years wheat

production in Canada has more than trebled. Manufactures have been doubled in volume of output. Horses have increased fifty per cent., but food animals have increased in that time less than twenty per cent. Now that the prices of all kinds of grains and fodder have advanced to record heights, the problem of making a profitable business out of cattle, sheep and swine is a difficult one to solve.

Increased production from the land is the basic argument in the campaign which has arisen as the result of the war. All other increased outputs in Canada must depend upon that which comes from the soil. Of late years the volume of business in Canada has not been proportional to the size and value of the yield of produce from the soil. The future was taken into account to an exaggerated degree, and in Western Canada particularly, banking, railway construction, municipal and all manner of civil works advanced until they were ten years ahead of their time. The land is now sought as the best economic means of squaring the nation's foundations and fighting the Empire's battles. This year the grain crop of Canada promises to be exceedingly large and it is a national undertaking to see that every farm is manned with an adequate supply of labor. It would seem necessary that many of the unemployed industrial workers in the towns and cities must serve their apprenticeship as farm laborers.

It has been said that the present crisis has brought into relief several very important facts. First, the transcontinental railway systems necessary for a considerable margin of further agricultural development are practically completed. Secondly the country is provided with industrial machinery for a population considerably in excess of its present numbers. Thirdly, the development of the primary industries of the country has been relatively inadequate. Fourthly, the financial situation is well in hand and presents no insoluble difficulties. In the first two cases there has been probably both waste and over anticipation of increase of population, but at all events, the work is done, the money has been borrowed, the responsibility is shouldered, and, as a matter of fact, the country as a whole is amply able to carry the burden. In any case we find ourselves in possession of some 36,000 miles of railway in reasonably good condition, and more than adequate to deal with the large task involved in conveying to market the primary products of a country situated as Canada is, with a small seaboard and a long, relatively narrow tract of country.

In regard to the internal economic condition of Canada, it is perfectly natural that the newer parts of the country should be the main centres of anxiety. Several cities in the west have been somewhat embarrassed by extravagant assessment of city values, and too much haste to proceed with municipal improvements ahead of actual requirements.

They have lost and are losing population, and the collection of taxes on their high assessment values has been somewhat difficult, but on the whole these towns appear to be meeting the situation with courage, show no disposition to consider the question of default

on their interest and in many cases are beginning the process of cutting down their assessments. Although last year prices for grain stuffs were high, it must be remembered that the crop was small. Still the principal and interest on farm mortgages were surprisingly well met. The effect of this year's large crop on the whole west must be very beneficial indeed, and it is quite inevitable that the western cities will get their share of the benefits accruing.

The trade returns of the Dominion for the last fiscal year reflect the general trade restriction both before and during the war up to March 31st last. As compared with the preceding year there was a net decrease of about 158 millions in the exports and imports of merchandise.

It is encouraging to note that for the first time in many years the balance of trade for the year in regard to imports and exports of merchandise is in Canada's favor, the total imports being $455,471,471 while exports are valued at $461,442,509. The imports of coin and bullion during the last fiscal year amounted to no less than $131,992,992 as compared with $15,236,305 for the preceding year. Canada's imports from the British Empire for the year totalled $116,272,787, a decrease of nearly $40,000,000 as compared with the preceding year. Imports from Great Britain which totalled $90,085,840 fell off by nearly $42,000,000. Imports from the British West Indies, however, increased by nearly $2,000,000. Imports of merchandise from the United States last year totalled $296,632,506, a decrease of nearly $100,000,000.

Canada's exports to British Countries during the year totalled $237,558,704, a decrease of nearly $10,000,000 nearly all of which was in exports to the United Kingdom. As compared with this Canada increased her sales of Canadian produce to the United States some $10,000,000 the total for the year being $173,320,798. During the year Canada bought from the United States $123,000,000 worth of goods more than she sold to the United States. In the case of Great Britain the Dominion sold $121,000,000 worth of goods more than she bought.

The increase in exports of merchandise during the year was due solely to the increased transportation through Canada of foreign produce, which was greater by some $28,000,000 than in the previous year and was made up principally of horses, oats and wheat bought from the United States for war purposes and shipped through Canadian ports.

The exports of Canadian produce show a decrease of $22,169,603. Exports from the mine decreased from $52,039,054 in 1914 to $51,740,989 for 1915; the fisheries from $20,623,560 to $19,687,068, agricultural products from $198,220,029 to $134,746,050.

On the other hand exports of animal produce increased from $53,349,119 to $74,390,743 and of manufactures from $57,443,452 to $85,539,501. The increase in the exports of animal produce reflects, of course, the large sales to the United States of beef cattle following the taking down by the United States of the tariff barriers.

The increase in the exports of manufactures is largely due to Canadian sales of war munitions to the Allies.

The effects of the war are seen in the figures of the trade with France and Germany. Imports from France last year totalled $8,449,186 as compared with $14,276,378. Exports to France totalled $14,595,705 as compared with $3,810,562 for the preceding fiscal year. From Germany Canada bought during the twelve months goods to the value of $4,314,805 as compared with $14,586,-223 for the preceding year. To Germany Canada sold last year goods to the value of $2,162,010 as compared with $4,423,736 in 1913-14. The total trade of Canada with Germany in 1913-14 amounted to $19,019,969. In 1914-15 it amounted to $7,248,996. This year it will be nil. The "Balance of Trade" which is in this country's favor by about $6,000,000 will be largely increased during the present fiscal year.

The following table published by the London *Daily News* and leaded, is interesting and directs attention to the population and resources of the belligerents as follows:—

Nation	*Population*	*Resources*
British Empire	439,000,000	$2,245,000,000
Russia	174,000,000	1,700,000,000
France (with colonies)	80,000,000	1,100,000,000
Italy	38,000,000	565,000,000
Japan	53,000,000	325,000,000
Belgium (including the Congo)	7,500,000	(unstated)
Servia	3,000,000	42,500,000
Montenegro	500,000	2,500,000
Total	795,000,000	$5,980,000,000

Against these forces are aligned:

Nation	*Population*	*Resources*
Germany	65,000,000	875,000,000
Austria	29,000,000	700,000,000
Hungary	21,000,000	470,000,000
Turkey	21,000,000	85,000,000
Total	136,000,000	$2,130,000,000

This table is interesting and the figures given sum up one result and that is final overwhelming triumph of the Allies.

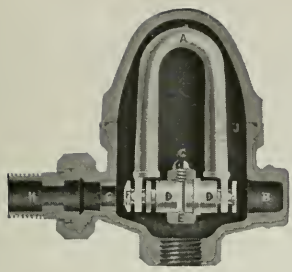
F. M. Buchanan, B.A.Sc., '15, has recently received the appointment as foreman on the Wayne County Concrete Roads, Michigan.

T. R. Banbury, B.A.Sc., '15, is with the Canadian Inspection Co., at the Empire Mfg. Co. Ltd., London.

W. M. Currie, '04, is vice-president and general manager of the Burlington Steel Company, Hamilton, Ont.

J. Chalmers, '94, is a consulting engineer. His address is 13012 104th Ave., Edmonton, Alta.

A NEW RADIATOR TRAP



The thermostatic member used in this valve consists of a specially designed spring-tempered steel tube, heavily copper plated and contains a volatile fluid, hermetically sealed, which is so sensitive that a change of one degree is sufficient to start the valve in operation. This tube is held in a central position by a guide, cast solid with the body of the valve. A cap nut is provided on the side of the valve directly opposite the seat through which the valve mechanism may be inserted, or for testing the operation of the valve while it is in service.

The entire valve mechanism is mounted on a sleeve which acts as a guide for the valve head, and also supports and holds the thermostatic member so that the movement due to expansion and contraction must open and close the valve. This sleeve is supported and held in position by a bridge which is cast solid with the valve body. The valve head is of bronze and is so arranged that any movement of the expansion member will cause the valve head to move forward or back. The valve seat is a tempered bronze seat inserted into the body of the valve.

When steam is turned on, the thermostatic tube is neutral, under which conditions the valve is wide open, giving the full valve area. The valve remains in this position until all the air and condensation have been removed from the radiator (or point to be drained), but just the instant steam arrives, the tube expands, closing the valve absolutely tight. As condensation forms, the temperature lowers and the tube contracts, moving the valve from its seat, thereby permitting the condensation to be discharged.

Owing to the re-evaporation of the condensation when passing from a slight pressure to vacuum, the vapors from the hot water are sufficient to actuate the tube, thus preventing any measurable amount of vapor from passing through the valve. Attention is directed to the exceptionally large valve-opening. Any scale, sand or other foreign matter which may enter the valve drops to the bottom, and the valve seat being at the side and in a vertical position is thus kept clean and free from any foreign obstruction.

This valve is absolutely noiseless in operation, its construction makes it impossible for the valve head to flutter, and due to the fact that the valve seat is in a vertical position, foreign matter will not lodge on it and cause a hum due to the steam wire drawing.

These traps are manufactured by Wm. S. Haines & Co., Philadelphia.

THE ENGINEERS

The ways of the Lord be manifold, He has fashioned divers men
To fret the Earth for a little space with labour, laughter and tears,
To strut in the light till the world forgets and buries them deep—and then
The Lord He stiffened His good right arm and fashioned the Engineers.

Where the naked ribs of the liner curve, and the straining rivets whine,
Where the plunging crosshead spatters the oil in the incandescent's glare,
Where the clanging coal scoop swings in the gloom, and the blistering clinkers shine,
Behold him—cool as an iceberg's foot—the Slave and the Master there.

When you come to the end of the old known land, to the far horizon's rim,
To the raw crude plain where the uplands lift and the mountains clamber sheer,
The small wise men of the ledger halt, and the call goes forth for him
Who laughs at the everlasting hills—the Master, the Engineer.

By lathe and chisel, by hammer and forge he is shaping the things that be,
He has harnessed the stream to his dynamo, he has said to the tides, "Beware."
He grubs in the echoing womb of the earth, and sits on the floor of the sea,
And rides athwart of the thunderstorm in the hollow caves of air.

Smooth and silent and very sure, he fingers the locking switch,
Where the yellow copper is glutted with death as it gleams on the marble wall,
And he turns on his heel when the red lamps wink, to balance his power and pitch
Through the gloom of the throbbing canyon streets the might of a water fall.

He weighs the world and the eye of a fly and he measures the light of a star,
And plays with a key at the end of a wire till the slumbering cities hear.
He whispers low and cradles his words on the curve of a waxen jar
That the bottom end of the earth may list to the voice of the Engineer.

He has come to grips with eternal truth, and he dallies not with lies;
He has ravished his mind of its small conceits and he knows not how to shirk,

For the Thing—the ultimate perfect Thing, is glimmering in his eyes
And a voice, a small reiterant voice, is whispering—"Will it work?"

When we come in time to the end of the road, to the step of the Golden Gate,
We shall see a fellow in overalls, and he'll probably stop and peer
To see how the gate is built, and then, if we only watch and wait
We shall notice him oiling the golden hinge—the beggar—the Engineer.

ALAN SULLIVAN, S.P.S., '89, in Popular Magazine.

PERSONALS

W. G. Collinson, B.A.Sc., '09. His address is 532 4th St., Niagara Falls, N.Y.

R. J. Campbell, '95. His present address is 1218 Corn Exchange Bldg., Chicago.

A. J. Campbell, B.A.Sc., '04, resides at Collingwood, Ont.

H. R. Carscallen, B.A.Sc., '08, is assistant hydrographer in Irrigation Branch of Department of Interior at Calgary.

A. Cameron, '06. His present address is care of Provincial Architect's office, Winnipeg.

A. B. Crealock, B.A.Sc., '15, is draughting for the Toronto Rapid Transit. His address is 61 Geoffrey St., Toronto.

Geo. F. Dalton, B.A.Sc., '14, is on Geodetic Survey work with the Department of Interior. His address is 342 McLaren St., Ottawa.

W. L. Dickson, B.A.Sc., '15, is with the Canadian Inspection Co., at the Empire Mfg. Co., Ltd., London, Ont.

E. R. Frost, B.A.Sc., '09, resides at 159 Wentworth St. N., Hamilton.

H. P. Frid, '11, is a member of the firm James Frid & Co. Ltd., consulting engineers, Hamilton. His address is 607 Bank of Hamilton Bldg., Hamltion.

H. J. Franklin, B.A.Sc., '14. His permanent address is 72 Delaware Ave., Toronto.

J. S. Galletly, B.A.Sc., '07, resides at Osahwa, Ont.

R. S. Houston, '06, his present address is care of Dominion Bridge Co., Ltd., Winnipeg.

L. J. Hayes, '03, now resides at 2434 Niagara Ave., Niagara Falls, N.Y.

R. A. Henry, B.A.Sc., '13, is with the Maritime Bridge Co. of New Glasgow. His address is Box 1017, New Glasgow, Nova Scotia.

J. E. Hanlon, B.A.Sc., '15, is a surveyor for the Hollinger Mine at Timmins, Ont.

Dion S. Halford, B.A.Sc., '15, is with the Consolidated Arizona Smelting Co., Humboldt, Ariz.

E. W. M. James, B.A.Sc., '09, now resides at 445 Rosedale Ave., Winnipeg, Man.

K. A. Jefferson, B.A.Sc., '15, is with the Canadian Inspection Co. at the Empire Mfg. Co. Ltd., London.

J. A. Knight, B.A.Sc., '14, formerly with the Foundation Co. of Montreal, has enlisted with the Third Cyclist Corps.

E. J. Laschingle, B.A.Sc., M.E., '92, is hydraulic and air power engineer with the Central Mining & Investment Corporation Ltd. His address is Box 4563, Johannesburg, S. Africa.

R. W. E. Loucks, '09, is inspector of surveys, Land Titles Office, Surveys Branch, Regina, Sask.

R. E. Lindsay, B.A.Sc., '14, residence, 282 Ossington Ave., Toronto.

J. T. Mogan, B.A.Sc., '15, is on the Toronto Harbour Commission work.

J. M. Muir, B.A.Sc., '15, is with the Department of Education, Toronto.

J. A. MacMurchy, '96, address is 1315 Elm Street, Wilkinsburg, Pa.

C.O.T.C. MEN WHO PASSED THE OFFICERS' EXAMINATIONS

Out of seven hundred University men who wrote on the examinations of the Canadian Officers' Training Corps, only 153 passed. This was due to the examinations being much more severe than formerly, and not because of the rumored differences between the C.O.T.C. and military authorities. The following is the list of successful candidates:—

L. S. Aldard, D. R. Agnew, J. W. Ansley, R. H. Barbour, V. A. Beacock, S. Beatty, E. G. Berry, C. H. Black, A. S. Bourinot, W. F. Bowles, H. S. Brewster, J. C. W. Broom, L. A. Broughton, H. D. Brown, P. B. Brown, R. A. Brown, G. F. Bryant, J. T. Burns, T. D. Campbell, J. R. Cockburn, G. M. Dallyn, W. A. Dean, S. H. Dixon, G. P. Dunstan, C. Feeney, C. B. Fisher, E. M. Fraser, R. A. Fraser, F. H. Galpin, J. A. Garvie, J. A. Gilchrist, R. V. Gordon, D. S. Graham, H. H. Graham, H. C. Green, E. W. Haldenby, C. W. Harris, R. M. Harvey, W. J. Hearst, J. E. Hill, F. W. Hepwell, A. M. Horner, E. Howell, A. H. Isbister, T. H. Jamieson, A. M. Jeffrey, F. M. Johnston, G. W. F. Johnston, F. B. Kenrick, G. W. Kaiser, J. A. Kingsmill, W. W. Lang, G. W. Lawrence, H. O. Leach, H. B. Little, M. I. Machell, D. Maclean, J. P. Magwood, J. A. R. Mason, A. W. McConnell, W. R. McGie, H. C. McKendrick, A. P. McKenzie, D. S. McPherson, J. H. Moxley, J. M. Muir, J. G. Murray, F. S. Parney, G. Pilkey, J. R. Pounder, J. D. Relyea, W. W. Ritchie, C. C. Robinson, B. J. Roberts, H. M. Rowe, R. A. Seymour, J. E. Sharman, W. L. Sagar, M. R. Shier, K. G. Sinclair, W. E. Smith, W. J. Southcombe, W. A. Steele, E. C. Tate, W. D. Thomas, H. R. Thomson, W. M. Treadgold, H. D. Wallace, A. L. Ward, H. S. Weldon, R. H. Williams, W. J. T. Wright, H. H. Wrong, L. E. Willmott, L. L. Youell, J. R. Robinson, W. Hegers, J. M. Aylward, W. H. Bonus, B. D. Carlyle, J. M. Cunningham, H. A. Elliott, J. A. Harston, J. R. Manning, L. M. Murray, R. B. Pichard, G. A. Snow, J. S. Wear, K. A. Jefferson, W. H. R. Gould, G. K. William, R. L. Killock, G. Rosser, A. L. Huether, G. W. Brown, T. M. Kerruish, E. Machell, H. C. Budd, W. A. Smelser, W. L. Dobbin, C. R. McCort, A. Chambers, F. L. Mitchell, C. R. Albright, W. T. Miller, J. S. Beatty, A. M. Boyd, F. C. Carter, R. S. Cassels, W. W. Davidson, M. L. Ellis, A. M. Garden, J. N. Garrow, E. L. Greene, R. W. Hart, J. S. Hodgson, R. A. Laidlaw, H. E. Manning, K. F. McKenzie, N. M. McLeod, W. B. McPherson, W. W. Parry, C. F. Ritchie, H. D. Scully, A. C. Snively, C. L. Wilson, E. V. Graham, C. B. Scott, H. P. Stewart, R. P. McCormack, R. B. Whitehead, D. W. Lang, D. B. Gillies.

DAVISON-HASTINGS

At Pittsburgh, Pa., in September, 1914, H. D. Davison, B.A.Sc., '13, of Bridgewater, Nova Scotia, was united in marriage to Miss Helen Hastings of Pittsburgh, Pa.

HAYES-O'BRIEN

At Albany, New York, on May 29, 1915, L. Joseph Hayes, '03, of Toronto, was united in marriage to Loretta M. O'Brien, of Albany, N.Y. Mr. and Mrs. Hayes will reside at Niagara Falls, N.Y.

DAVISON-MARSHALL

In January last at Bridgewater, Nova Scotia, Mr. R. F. Davison, '13, was united in marriage to Miss M. Marshall, of Annapolis, Nova Scotia.

SARA-HANNA

Mr. and Mrs. A. E. Hanna, 1123 Grosvenor Ave., Winnipeg, announce the engagement of their only daughter, Evelyn B., to Mr. Richard A. Sara, B.A.Sc., E.E., '09, youngest son of Mr. and Mrs. J. H. Sara, Toronto. The marriage will take place on September 29th.

SHEARER-PUGSLEY

Rev. Will and Mrs. Pugsley, Yorkville Ave., announce the engagement of their daughter, Bessie May, to Mr. Harry Foster Shearer, B.A.Sc., '08, Toronto, son of Mr. and Mrs. Charles E. Shearer, Vittoria, Ont. The marriage will take place early in September.

PENNINGTON-CHIPMAN

Mr. and Mrs. Willis Chipman announce the engagement of their daughter, Gertrude Elma, to Charles Wakley Pennington, B.A.Sc., '14, of Dundas. The marriage will take place quietly early in September.

C. P. McGibbon, '04, resides at 124 James St., Hamilton.

V. McMillan, B.A.Sc., '09, is with the Canadian Inspection Co. at the Empire Mfg. Co., London

O. B. McCuaig, B.A.Sc., '04, C.Q.M.S. No. 5302, No 2 Field Co. Divisional Engineers, First Contingent, Army P.O., London, Eng.

H. C. McMordie, B.A.Sc., '08, formerly with the Trussed Concrete Steel Co. at Winnipeg, has volunteered for overseas service and we believe he received a commission with a Winnipeg battalion.

O. W. Martyn, B.A.Sc., '09, is a member of the firm Martyn & MacDonald, civil engineers and surveyors. Address, Box 443, Swift Current, Sask.

A. W. R. Maisonville, B.A.Sc., '10, is with the Dominion Bridge Co., Montreal.

C. R. McCort, B.A.Sc., '15. Address, 519 Clark Ave., Westmount, Que.

EDITORIAL COMMENT

NEW SUBMARINE ENGINES

In this great war for humanity which is being waged in Europe, one thing stands out above all others: namely, that this is primarily a war waged by machines against machines. Mechanical genius is now being refined in the great crucible of immediate adaptability to present ends. The weak or fundamentally incorrect is tried and immediately wasted. The strong is improved and adapted to further uses. Above all the germ of new ideas is being sought, and it may be that in the utilization of compressed air for propelling the submarine when submerged Mr. Tygard has presented a new line for experiment. We have just the rough outline of the idea presented to us in the present article and can only hope for a fuller demonstration in the future.

There are two or three points worth considering, however. Granted the fact of noxious gases from electrical storage batteries, of what increased purity would the compresed air be after being exhausted from the rotary air engine? Again is it possible in the same time to store the same working quantity of energy in the air as could be stored in batteries. Further would not the exhaust from such an engine very materially lower the temperature of the submarine even to the point of frigidity? Another interesting point which would call for explanation is how the exhaustion overboard of the gases from the oil engine is to be accomplished given the air pressure in the submarine as excessive and the craft submerged. Would it not be as practical, if at all possible, to exhaust the air direct?

All of these questions bear vitally on the feasibility of the idea. They have, no doubt, been met by Mr. Tygard from the outset, and we await with interest a more complete description.

BOARD OF ENGINEERS

Has the engineering body of Canada realized as a whole that this war is to be to a finish and that that finish is far away? Have they appreciated the fact that before this war is over conditions in Canada must come to that of England at the present time. Everything will have to be made subservient to the war,—bridges, buildings, paving streets, municipal works of all sorts, must all eventually become of secondary importance? What can the engineers do? At least a partial answer to this is not hard to find.

England at the present time is being gone over with a fine toothed comb by the British Munition Department and its auxiliary advising boards. Factories of all kinds are being adapted to the manufac-

EDITORIAL COMMENT

ture of war supplies,—cloths, guns, ammunition, and equipment. Matters are to an extent being taken out of the owners' hands because of necessity. What is the result but that a more cheerful spirit is pervading the country and order is coming into being.

Take the United States, a country not at war, and from present indications not likely to be. Secretary of the Navy Daniels has announced the formation of a board of the most eminent creative geniuses of that country, headed by Thos. A. Edison; for what purpose? To apply their gifts to the improvement and perfecting of the arms of the United States. All this, mind you, before war is contemplated.

Now let us look at Canada. We have done wonders. From a production of munitions practically nil we have attained an output of over 25,000 shells per day. We have the best aeroplane engineers working constantly. Our woollen mills are keeping up with present demands. But what more might be done? Ammunition and guns with more ammunition is the cry from Europe and we pat ourselves on the back and point to our present output. But here is the chance for Canadian engineers to do something patriotic. At present a manufacturer, before he can obtain a contract for munitions, has to satisfy the authorities of his ability to fulfil that contract. He is put to the trouble of engaging engineering skill to rearrange his plant to meet new conditions. These alterations are made in no standard way, and as has often been the case, have had to be further revised.

Why should the engineers wait for the Canadian Government to move towards lending a hand to all those plants which might aid in the production of war supplies. Why do they not rather approach the government and show the need for concerted and thoughtful action. What is needed is a business like stocktaking of all the possible sources of manufacture in Canada. Then the best engineering brains of Canada under Governmental control and working to the Government's own specifications, should step in and take charge of the alterations for the owners and carry the work to a speedy and correct end. An engineering body of this kind working with complete information could accomplish wonders in Canada and this concentration of energy would not stop there. It would awake the country as in no other way, to the seriousness of the time. It will ultimately come, but why wait for governmental action? Canada has the engineers, and if they have a proper understanding of the word "patriotism" it is up to them to impress the government with the need for immediate scientific action, in remantelling our manufactures, etc., for the present work of the Empire.

EDITORIAL COMMENT

ATTENTION OF ALL

As a means of increasing the "get-together" spirit of "School" men, now that the Exhibition is on, let us ask each and every graduate to call at the office of the Society in the Old Red Building and make themselves known while in town. Make this office the headquarters for your stay and utilize the conveniences of the Society at this time. Our new and comfortable smoking room, in which you will find all the daily papers are at your disposal, as is also our library. Get in touch with the other fellow once more; find out what is being done by the Society; learn the problems we are trying to meet and let us profit by your experience and advice. All graduates anticipating a visit to the city at this time are requested to send their name and probable city address for our Exhibition registry and we will do what we can to get you in touch with other School men. *The office is open every day from 9 a.m. to 5 p.m. (excepting Saturday, and the telephone number is College 5000.* The West door *only* is open.

ON ACTIVE SERVICE

G. R. Johnson, B.A.Sc., '13, with the King Edward Horse, Machine Gun Division, 12th Brigade B. E. Force.

Grant Gooderham, B.A.Sc., '15, and **R. D. Delamere, B.A.Sc., '14,** have completed their flying course at Toronto and received their commission in the Imperial Service.

G. K. Williams, B.A.Sc., '10, has joined the Aviation Corps.

C. Hewson, '17, with the Aviation Corps.

Geo. G. MacLennan, '10, has enlisted for overseas service with the Aviation Corps.

J. A. Knight, B.A.Sc., '14, has enlisted with the Third Overseas Cyclist Corps, which is being recruited from the Corps of Guides.

Lieut. E. V. McKague, B.A.Sc., '15, has received a commission with the Third Overseas Cyclist Corps.

Capt. G. B. Schwartz, '16, is in command of the Third Overseas Cyclist Corps.

Lieut. R. D. Galbraith, B.A.Sc., '15, has received a commission in the 92nd Battalion with the Queen's Own.

H. C. McMordie, B.A.Sc., '08, we believe, has received a commission with a Winnipeg Battalion for overseas service.

Lieut. A. P. Linton, B.A.Sc., '06, has received a commission with the 68th Battalion C.E.F. at Regina, Sask.

Lieut. R. K. Northey, B.A.Sc., '11, is also with the 68th Battalion recruiting at Regina, Sask.

Wm. A. O'Flynn, B.A.Sc., '11, has accepted a position as 2nd chemist for the Mond Nickel Co., Coniston, Ont.

J. J. Philips, B.A.Sc., '13, is installing machinery for Abitibi Power & Paper Co., Iroquois Falls, Ontario.

J. A. Ryckman, '06, is field engineer on the Bloor St. Viaduct, Toronto. Address 300 Clendenan Ave., Toronto.

D. C. L. Raymond, B.A.Sc., '04, is with the Raymond Construction Co. of Montreal, who are doing concrete work in connection with the Rosedale section of the Bloor St. viaduct.

UNKNOWN ADDRESSES

OUR READERS WILL CONFER A FAVOR IF THEY WILL KINDLY ADVISE US OF THE CORRECT, OR MOST RECENT KNOWN ADDRESSES, OF ANY OF THE MEN LISTED BELOW

Acres, H. G., '14.
Alexander, J. H., '04.
Barrett, J. H., '03.
Bertram, G. M., '01.
Binns, R. E., '13.
Boswell, W. O., '11.
Boulton, W. J., '09.
Burgess, J. R., '10.
Bowman, A. M., '86.
Brackenreid, '11.
Brown, D. B., '88.
Brown, H., '11.
Brown, E. I., '08.
Brown, E. W., '09.
Bruce, W. J., '07.
Burnham, F. W., '04.
Cameron, M. G., '09.
Campbell, A. W., '06.
Campbell, J. E., '08.
Carey, B., '99.
Chambers, E. V., '14.
Chantrell, E., '05.
Charlebois, J. P. C., '08.
Chisholm, D. C., '10.
Christie, V., '06.
Clark, G. T., '06.
Clendenning, A. C.
Coulter, G. P., '07.
Darroch, J., '08.
DeGuerre, F. C., '11.
Derham, W. P., '09.
Dowling, F., '05.
Elliott, J. C., '99.
Evans, J. H., '11.
Evans, S. D., '07.
Evans, S. L., '08.
Flynn, C. C., '11.
Foreman, W. E., '99.
Forester, C., '93.
Francis, C. C., '08.
Gray, J. E., '09.
George, R. E., '03.
Gourley, W. A., '03.
Harris, H. C., '13.
Heebner, M. B., '11.
Horton, J. A., '03.
Holmes, H. E., '11.
Hull, H. S., '95.
Johnston, G. K., '03.
Jones, G. R., '06.
Kean, D. L., '09.
Keefer, A. H. E., '09.
Keys, W. R., '08.
Killip, W. C., '08.
King, C. F., '97.
Lawson, W. L., '92.
Lott, A. E., '87.
Macdonald, F. R., '08.
Macdougall, A. C., '01.
MacFarlane, E. D., '09.
McKay, A. G., '07.
McKay, J. T., '02.
McKenzie, D. W., '05.
MacLachlan, W. A., '09.
McLean, W. N., '05.
McLeod, G., '09.
McLeish, A. G., '11.
McPherson, J. A., '06.
Macpherson, N. W., '09.
McTaggart, A. L., '94.
Malone, J. E., '08.
Martin, F., '87.
Matheson, W. C., '01
Maus, C. A., '03.
Mennie, R. S., '02.
Milligan, G. L., '08.
Mitchell, L. C., '11.
Montague, F. F., '06.
Munro, F. V., '03.
Murray, J. D., '07.
Niebel, E. H., '11.
Nourse, A. E., '07.
O'Brien, E. D., '05.
O'Gorman, C. A., '09.
Oliver, J. P., '03.
Parke, J., '04.
Paton, T. K., '07.
Paulin, F. W., '07.
Pearce, K. K.
Pearson, C. L., '11.
Pope, A. S. H., '99.
Roaf, J. R., '00.
Sanders, W. K., '06.
Shipley, A. E., '98.
Shortt, J. H.
Smith, F. L., '10.
Squire, G. E., '11.
Stamford, W. L., '08.
Stuart, J. L. G., '07.
Szammers, C. F., '11.
Taylor, J. W. R., '08.
Thomas, V. C., '08.
Thomson, J. E., '06.
Venney, L. T., '06.
Williamson, D. A., '98.
Wilson, F. F., '09.
Wilson, W. H., '10.
Wilkes, G. H., '11.

PERSONALS

D. F. Robertson, D.L.S., '04, is surveyor in the Department of Indian Affairs, Ottawa.

H. L. Roblin, B.A.Sc., '11, is with the Canadian Inspection Co., at Galt. Address care of Y.M.C.A.

H. A. Ricker, B.A.Sc., '08. Residence, 93 Sanford Ave., S., Hamilton.

C. C. Rous, B.A.Sc., '13, resides at 59 St. Cyrille St., Quebec.

A. A. Richardson, B.A.Sc., '15, has recently accepted a position in charge of some harbour work for the Canadian Stewart Co., Toronto.

N. H. Sturdy, '05, residence, 426 Emerson Place, Youngstown, Ohio.

G. C. Story, B.A.Sc., '15, is with the McCormick Mfg. Co. Ltd., London, as electrician. Address 579 Colborne St., London, Ont.

H. V. Serson, '05. Address, Box 107, Arnprior, Ont.

W. Snaith, '07, is with the Thor Iron Works Ltd., Toronto.

P. H. Stock, '09. Address 12 Fernwood Park Ave., Toronto.

K. E. Shaw, B.A.Sc., '13, is with the Dominion Sugar Co. Ltd., of Wallaceburg, preparing plans and estimates for a proposed 1,200 ton sugar beet factory to be erected at Chatham.

P. M. Sander, '04, is chief hydrographer in the Irrigation Branch of Department of Interior at Calgary. Address P.O. Drawer 2318, Calgary.

R. O. Standing, B.A.Sc., '14, is with Goldie & McCullough Ltd., Galt. His address, 40 West Main St. North, Galt.

M. L. Smith, B.A.Sc., '11, formerly associate editor for MacLean Publishing Co., Toronto, has accepted the position in charge of engineering at the New Technical School, Toronto.

W. H. Stevenson, B.A.Sc., '01, is secretary of the Power Plant Specialty Co., Monadnock Block, Chicago.

C. P. Sills, B.A.Sc., '11, is now at Seaforth, Ont.

E. H. Scott, B.A.Sc., '15, is guiding tourists throughout northern Ontario for the summer.

R. G. Scott, B.A.Sc., '15, is on geological survey work around Revelstoke.

J. B. Stitt, B.A.Sc., '15, is with the Braden Copper Co., Rancagua, Chile, South America.

J. E. C. Stroud, B.A.Sc., '15, is assistant chemist on smelter at Anyox, B.C.

H. W. Tye, '08, is now at Balcarres, Sask.

W. V. Taylor, '93, is principal assistant engineer to the Quebec Harbour Commissioners.

T. L. Villeneuve, '08, is with the Department of Public Works, Chicoutimi, Que.

O. T. G. Williamson, B.A.Sc., '09, resides at 1345 North Shore Ave., Chicago, Ill.

F. H. Wrong, '11, resides at 355 Bedford St., Sandwich, Ont.

J. A. Whelihan, '03, is ranching somewhere in the west. Try Box 165, Regina, Sask.

H. A. Wood, B.A.Sc., '15, is in charge of surveys for the Eastern Division of Toronto Harbour.

DIRECTORY OF THE ALUMNI

Gibson, M. M., '10, and **Gibson, W. S.,** '04, are members of the firm Gibson & Gibson, civil engineers and surveyors, Toronto.

Gibson, N. R., '01, 550 Confederation Life Building, Toronto.

Gillespie, P., '03, is associate Professor, Department of Applied Mechanics, University of Toronto.

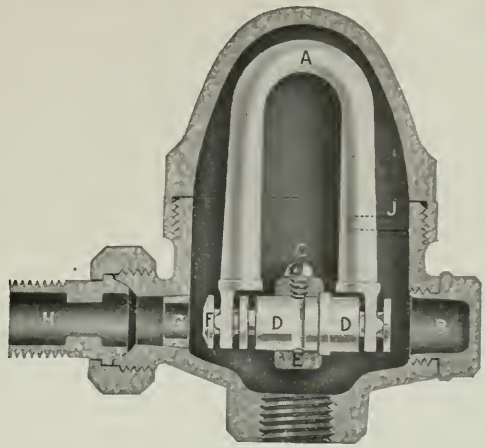
Gillies, A., '07, is with the C.N.O. Ry. at Quebec, Que.

Glover, A. E., '09, is engaged in surveying in Edmonton, Alta.

Goad, V. A. E., '10 is a partner in the firm of the Chas. E. Goad Co., surveyors and civil engineers. He was in charge of their Montreal office when last heard from.

Goldie, A. R., '93, is a member of the firm of Goldie & McCulloch Co., Limited, Galt, Ont., as manager.

(*Continued on page x*)



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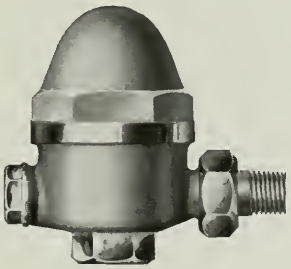
FOR
VACUUM AND VAPOR HEATING

The true efficiency of a vacuum trap is best demonstrated by a comparison of its performance with others under the same reliable test.



Twenty years' experience in the manufacture of thermostatic valves has produced a trap the perfection of which is best appreciated by its many users and may be seen from the results of the tests published in this issue.

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THE ARTHUR S. LEITCH CO.
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TORONTO

(*Continued from page 120*)

Goodall, J. N., '04, is engaged in civil engineering in this city.

Gooderham, A. E., '09, is chemical analyst for Gooderham & Worts, Toronto.

Gooderham, J. L., '11, is assistant chemist in the distilleries of Gooderham & Worts, Toronto.

Goodeve, V. S., '10, is at Phoenix, B.C., with the South Kootenay Water Power Co.

Goodridge, H., '10, city engineer's department, Edmonton, Alta. Address 883-23rd St.

Goodwin, A. C., '02, was with the Aluminum Co., Pittsburgh, Pa., when last heard from. We have no other address for him.

Goodwin, J. B., '92.

Gordon, J. P., '04, is assistant chief engineer Hudson Bay Ry., Scott Block, Winnipeg.

Gordon, W. A., '10. We have not his address.

Gourlay, V. F., '10, is a member of the Canada Iron Corporation, Galt, Ont.

Graham, C. W., '06, is assistant chemist Dominion Experimental Farm Ottawa, Ont.

Graham, E. B., '10, is with the Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.

Graham, G. W., '07, his home address is Eugenia, Ont. We have no record of his professional work.

Graham, D. A., '09 is resident engineer with the Canadian Northern Pacific Railway, Hope, B.C.

Grant, W F., '98, is city engineer of Sault Ste Marie, Ont.

Grant, R R., '09, is engaged in surveying and contracting, with offices in Toronto.

Grassett, C. S, '07. We have not his present address.

Grassie, C. A, '08. His home address is Welland, Ont.

Gravely, T. G., is on shell inspection work in the shops of John Bertram & Sons Ltd., Box 158. Dundas Ont.

Gray A., '04, is with the St. Lawrence Starch Co., Port Credit Ont.

Gray, A. T., '97 is designing engineer on steam turbines, General Electric Co., Schenectady. N Y

Gray, E. R., '13, is Divisional Engineer, east of Yonge St., for the Sewers Department, City Hall, Toronto.

Gray, J. E., '09, was with the Transcontinental Ry., Edmonton. Alta., as instrument man, when last heard from.

Gray, W. W., '04, is with the Edmonton Light & Power Co., Edmonton, Alta.

Greene, A. E., '11, has 291 Stewart St., Peterboro, for his address.

Green, R. E., '11, is manager of the Oxford Motor Sales Co., Toronto, Ont.

Greene, P. W., '06, is a member of the firm of Kortwright & Greene, civil engineers, Toronto.

Greene, R. L., '10, is engineering salesman at Ottawa for the Canadian Allis-Chalmers Co., Limited, Founders and Engineers, Toronto.

Greene, W. H., '09, is assistant city engineer, Moose Jaw, Sask.

Greenwood, W. K., '04, is engineer for Orillia, Ont., Water, Light & Power Commission.

Guernsey, F. W., '95 is engineer for the Consolidated Mining & Smelting Co., at Trail, B.C.

Gulley, C. L., '08, is with the Northern Electric & Mfg. Co., Limited, Toronto, as sales engineer.

Gunn, W. W., '09, is in the Toronto office of the Dominion Bridge Co. His address is 243 Quebec Ave., Toronto.

Gurney, W. C., '96, is vice-president of the Gurney Foundry Co., Limited, Toronto.

Guest, W. S., '00, is lecturer in electrical engineering, University of Toronto.

Guy, E., '99, is in Toronto at present. His address is 541 Euclid Ave.

H

Hackner, J. W., '08, whose home is in Sandford Ont. is assistant engineer for the Department of Public Works, Ontario.

Haddock, J. P., '13, was in the test department of the Canadian General Electric Co., Peterborough, when last heard from.

Hagarty, R E. W., '07, is manager of the Vancouver office of Western Pavers, Ltd.

Haight H. V., '96, is chief engineer of the Canadian Ingersoll Rand Co., Sherbrooke, Que

Hall, H. G., '11, is assistant superintendent, Woodstock Water & Light system, Woodstock Ont.

(*Continued on page xii*)

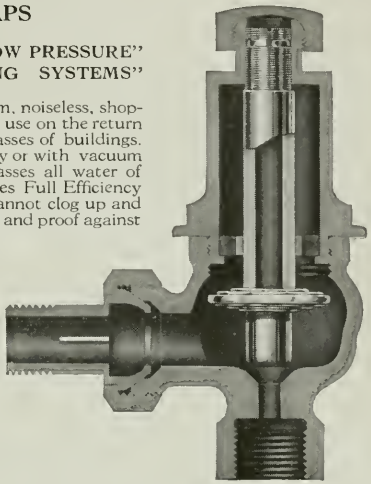
99.3% EFFICIENCY OF RADIATOR HIGHEST OF ALL

SEE PAGE 83 TO 93 OF THIS ISSUE "RADIATOR TRAPS AND TEST DATA"

MARSH ORIGINAL REFLUX
THERMOSTATIC TRAPS

FOR RADIATORS AND COILS OF "LOW PRESSURE" "VAPOR" AND "VACUUM HEATING SYSTEMS"

An All-Metal, Phosphor Bronze diaphragm, noiseless, shop-adjusted, self-cleaning Thermostatic Trap for use on the return end of radiators and coils of all sizes and classes of buildings. For any two pipe system operating by gravity or with vacuum pump on return line. Eliminates all air, passes all water of condensation, does not leak steam and insures Full Efficiency of heat unit. Quick circulation of steam—cannot clog up and when cold, is wide open—always self-draining and proof against freezing.



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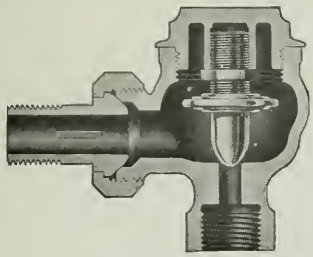
The Reflux Junior Trap is recommended for small radiators and coils. This Trap for the smaller units and the Original Reflux Trap for the large units will make an ideal installation.

The Reflux Junior Trap is especially adaptable for two pipe gravity work and vapor systems.



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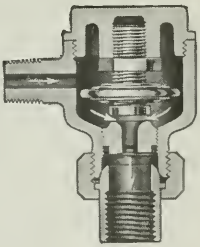
An All-Metal, Phosphor Bronze diaphragm, shop-adjusted drain pipe Air Line Valve. Operates automatically with or without mechanical suction on return air line. Automatically passes all air, hot or cold, into the return air line, but closes the instant steam has circulated through the entire heat unit and up to the valve. Extra heavy cast brass valve with all lathe cut threads. Adjusted at factory to work automatically at all varying pressures up to 15 lbs.



WRITE FOR SPECIAL LITERATURE

CANADIAN SELLING AGENTS

TAYLOR-FORBES COMPANY, Ltd., GUELPH

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Taylor-Forbes Company,
1088 King St. West

MONTREAL
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Mechanics Supply Co., Agents,
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WINNIPEG
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Agents

ST. JOHN, N.B.
W. H. Campbell, Agent,
16 Water St.

VANCOUVER
Taylor-Forbes Company,
1070 Homer St.

(*Continued from page x*)

Hall, K., '07, is assistant engineer C.N.R. Peace River Branch. Address mail to A. T Fraser, district engineer C. N. Railway, C.N.R. depot, Edmonton, Alta.

Hamer, A. T. E., '01, is on the engineering staff of the Canadian Northern Ontario Railway, and is resident at Cochrane, Ont.

Hamilton, J. F., '03, is a member of the firm of Hamilton & Young, Dominion Land Surveyors and Civil Engineers, Lethbridge, Alta.

Hamilton, C. B., '06, is owner and general manager of the Hamilton Gear and Machine Co., Toronto, Ont.

Hamilton, C. T., is a member of the firm Johnston & Hamilton, engineers and contractors and D. and B.C. Land Surveyors, 73 Exchange Bldg., 142 Hastings St. W., Vancouver, B.C.

Hamilton, G. M., '11, is on the engineering staff of the Welland Ship Canal. His address is Box 57, Humberstone, Ont.

Hanley, S.C., '93, used to be with the Midland, Ont., Engine Works Co. We do not know his present location or employment.

Hanlon, J. E., '15, with the Hollinger Mines, Timmins, Ont.

Hanes, G. S., '03, is mayor of North Vancouver, B.C.

Hanning, G. F., '89, whose home is in Toronto, is divisional engineer for the Canadian Northern Railway at St. Eustache, Que.

Hara, L. D., '04, is in St. Catharines, Ont., as superintending engineer on the Welland Canal construction.

Hare, R. A., '07, is in charge of the test department of the Canadian Crocker Wheel Co. at St. Catharines, Ont.

Harcourt, F. Y., '03, is assistant engineer, Department of Public Works for Ontario, at Port Arthur, Ont.

Harcourt, H. E., '11, is resident engineer, sewer department, city of Toronto. He is also secretary-treasurer for J. H. Tromanhauser Co. Ltd., engineers, architects and contractors, Temple Building, Toronto.

Hare, W. A., '99, is president and managing director of the Hare Engineering Co., Limited, 115 King street east, Toronto.

Harkness, A. H., '95, is senior member of the firm of Harkness & Oxley, consulting structural engineers, Toronto, Ont.

Harkness, A. L., '06, was in the engineering offices of the St. Lawrence Bridge Co., Montreal, Que.

Harper, C. J., '09, is in Collingwood, Ont., at present.

Harris, C. J., '04, resides in Brantford, Ont., in the employ of the Brantford Screw Co.

Harris, J. H., '10, is superintendent for W. Harris & Co., manufacturers of glue, fertilizers, etc., Toronto, Ont.

Harris, F. K., '09, is with W. Harris & Co., Toronto.

Harris, R. C., was resident engineer for C. P. Ry. at Medicine Hat, Alta. We are not certain of his present address.

Harrison, R. L., '06, division engineer with Mackenzie, Mann & Co. He resides at 295 Carlton street, Toronto.

Harrison, F. W., '05, is engineer for H. D. Best Co., builders, New York.

Harrison, E., '06, is senior member of the firm of Harrison & Ponton, engineers and surveyors, Calgary, Alta.

Harston, R. G. L., '09, is superintendent for W. S. Tomlinson & Co., contractors, Toronto, Ont.

Hartney, J. C., '06. We do not know his present address or occupation.

Harvey, C., '01, resides in Kelowna, B.C. He has a practice as consulting civil engineer and land surveyor.

Harvey, D. W., '09, is assistant engineer of railways, department of works, Toronto. Address, 359 Spadina road.

Harvie, N. J., '10, whose home is in Orillia, Ont., has no record of professional employment with us.

Hastings, M. B., '10, is sales engineer for A. H. Winter Joyner, Limited, electrical supplies, Toronto.

Haultain, H. E. T., '89, is Professor of Mining Engineering, University of Toronto. He also has an office as consulting engineer at 123 Bay St., Toronto.

Haviland, F. L., '08, is with the Hamilton Bridge Works Co., Hamilto, Ont., in the engineering department.

Hawley, H. A., '13.

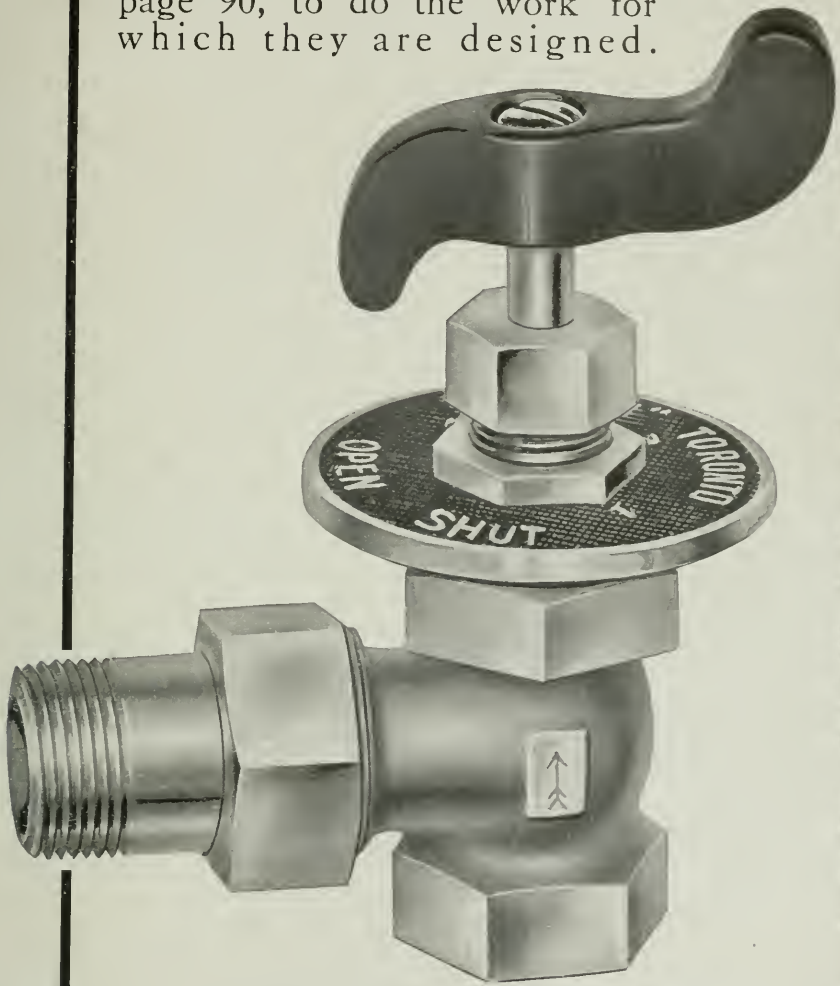
Hay, C. O., '09, deceased, September 5th, 1911.

Hayes, L. J., '03, is with the Star Electric Co., Niagara Falls, N. Y. His address is 2434 Niagara Ave.

Hayman, A. W., '13, is engaged in general contracting with the John Hay-

Continued on page xiv)

The "Welo" Modulation Valve
(with a real modulation) is guaranteed, including its worthy member shown on page 90, to do the work for which they are designed.



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(*Continued from page xiv*)

Holden, O., '13, is with the Hydro-Electric Power Commission, Toronto, Ont.

Holmes, A. E., '09, is in Montreal, Que., with the Canadian Westinghouse Co. as sales engineer.

Holmes, C. R., '09, is in Detroit, Mich., with the Electric Storage Battery Company.

Hookway, C. W., '06, is with the Westinghouse Manufacturing Co., Hamilton, Ont.

Hoover, O. H., '10, is in the Irrigation Dept., Calgary, Alta.

Hopkins, P. E., '10, is stationed at Porcupine, Ont., for the Ontario Bureau of Mines.

Hopkins, R. H., '06, has been appointed signalling officer of the 39th Battalion, Belleville, Ont.

Horton, J. A., '03, was in Northern Ontario when last heard from, several years ago.

Hoshal, G. C., '09, is with the Hydro-Electric Power Commission of Ontario and is now located at St. Thomas, Ont.

Houston, R. S., '06, is with the Dominion Bridge Co., Ltd.

Howard, J. T., '13, is on the staff in engineering at University of Toronto as demonstrator in drawing.

Howlett, T. F., '13, is in the West at present.

Huber, W., '06, is assistant to the chief engineer, Department of Public Works, Toronto.

Huether, D. J., '08. We do not know his address.

Huether, A. D., '08, is a member of the engineering staff of the city of Toronto, main drainage works.

Huff, A. J., '11, is in Edmonton, Alta., with the Huff Gravel Co., Limited.

Huffman, K., '11, whose home is in Toronto, is with Mackenzie, Mann & Co., construction department.

Hughes, C., '09, is on active service with second contingent.

Hugh, E. E. H., '14, is draughting with the Mound Nickel Co., Coniston, Ont.

Hull, H. S., '95, was with the Cambria Steel Co., in their works at Johnstown, Pa., as structural engineer when last heard from.

Hull, A. H., '06, is assistant electrical engineer in the Toronto office of the Ontario Hydro-Electric Power Commission.

Hunter, A. E., '09, has no address with us.

Hunter, A. N., '08, is with the Canadian Inspection Co., at Detroit. His address is c-o Detroit Rounding, Jefferson Ave. W., Detroit, Mich.

Hutcheson, J., '90, is on the staff of the Department of Lands, Forests and Mines, Toronto.

Hutchings, W., '14, is assayer, O'Brien Mine, Cobalt, Ont.

Hutton, C. H., '07, formerly with the Dominion Power Co., of Hamilton, Ont., as electrical engineer, is now living in Toronto.

Hyatt, H., '11, is assistant engineer for P. Lyall & Sons Construction Co. Limited, Toronto.

Hyland, H. M., '07, is a member of the Hyland Construction Co., railroad contractors, Toronto.

Hyman, E. W., '07, lives in London, Ont., where he is assistant superintendent of the London Electric Co.

Iler, S. B., '08, is assistant engineer with the Brantford Hydro-Electric System, Brantford, Ont.

Ingles, C. J., '04. We understand his present address is Welland, Ont.

Innes, W. L., '90, is general manager of the Dominion Canners Limited plants at Simcoe, Ont.

Ireland, L. G., '07, is manager of the Brantford Hydro-Electric System, Brantford, Ont.

Ireson, E. T., '13,

Irvine, J., '89, deceased.

Irwin, H., '09, is managing editor of The Canadian Engineer, Toronto.

Irwin, W. J., '10, is with the Westinghouse Electric and Manufacturing Co., East Pittsburgh, Pa.

Isbister, J., '09, is engaged on development work with the Onaway Electric Light and Power Co. Address, Onaway, Mich.

Jackes, F. P., '09, is commercial engineer for the Bell Telephone Co., Toronto.

Jackson, J. G., '03, was at Kingston, Ont., when last heard from.

Jackson, F. C., '01, is a member of the firm of Jackson & Connelly, railway contractors, La Tuque, P.Q.

Jackson, W., '07, is at 11 W. 12th street, Columbus, Ga., and is resident engineer on the new water works of that city.

Jackson, C. B., '07, is in Kenilworth, Ill., in the estimating department, C. Everett Clark Co., Limited.

Jackson, J. E., '09. His home is at Oxford Centre, Ont.

Applied Science

INCORPORATED WITH

TRANSACTIONS OF THE UNIVERSITY OF TORONTO ENGINEERING SOCIETY

Old Series Vol. 27 TORONTO, JUNE, 1916 New Series Vol. X. No. 5

THE UNIVERSITY AND INDUSTRIAL RESEARCH

By Dean W. H. Ellis

Among the treasured possessions of the library of the University is a set of the Annales de Chimie, the gift of the seventh Duke of Devonshire through the Committee formed in the Old Country to aid in replacing the loss caused by the disastrous fire of February 14th, 1890.

The set is complete from beginning of the series to the date of the fire and on the fly-leaves of the earlier volumes is stamped the honoured name of Henry Cavendish, who was the grandson of the second duke.

The first volume, as we read on the title page, was conducted by M. M. Guyton de Morveau, Lavoisier, Mouge, Berthollet, de Fourcroy, le baron de Dietrich, Hasenfratz and Adet. In 1791 the editors became Mm. Guyton ci-devant de Morveau. Dietrich had dropped his title of baron and de Fourcroy the aristocratic "de." Then follows a gap during which the Annales were not published and when in 1797 the editors' names again appear as les citoyens Guyton, Mouge, Fourcroy and the rest, the name of Lavoisier is not among them for that gap in her annals is the record that science has made of the Terror and the Terror had sent Lavoisier to the guillotine with the mocking words, "The Republic has no need of savants." From this delirium the Republic quickly awoke and her penitence for her murdered savants was bitter and sincere.

The avant-propos of the volume of the Annales de Chimie for the year V. of 1797 reads as follows:—

The Annales de Chimie have been interrupted for three years after the publication of the 18th vol. The necessity of occupying oneself solely with the defense of the Republic, the events of the revolution, the public functions of the authors, are the natural causes of this suspension. But the time has not been entirely lost for science. Chemistry above all has been cultivated with a success of which all citizens have been witnesses. She has created for the defence of the fatherland resources and means truly unexpected. Her immediate utility for the most pressing needs of society renders her more precious and commendable than ever in the eyes of the friends of mankind and of all good, true citizens. Also the number of those who study chemistry increases every day; also it becomes

one of the bases of instruction in all modern schools and above all in those which attain to the highest degree of human knowledge.

Among all the civilized nations where one works without relaxation in perfecting reason (ou l'on travaille sans relâche au perfectionnement de la raison) the sciences which influence territorial and industrial productions, and among which chemistry holds to-day the first rank, are held in general esteem. The cultivation of the fields, the multiplication of animals, the establishment of manufactures, the exchange of the creations of industry for the production of other peoples,—these are the true sources of the prosperity of nations in which all men are called to assist and where each will find his private enjoyment in serving his country.

Chemistry illuminates the practice of the arts; without it one can neither hope for constant products nor economy in processes nor perfection in operations. From failure to appreciate the advantages of chemistry and to make themselves acquainted with its results, manufacturers have often committed errors which have cost them the loss of their establishment. Within the last few years a mere handful of clever chemists have become manufacturers and already a crowd of processes have been rectified; and new arts have been created. France has ceased to be tributary to other nations for a great number of useful products. The preparation of mineral acids, of the different salts, of metallic oxides, the dye works, the glass works, so multiplied in France in the last fifteen years are authentic proofs of the unappreciable advantages of chemistry. Without the light of this science should we have made the quantity of saltpetre, of gunpowder, that we have manufactured in the last four years? Should we have had the copper, the iron, the steel, the potash, the soda, the leather and so many other precious materials which we have employed to vanquish our enemies and to sustain our existence? Without chemistry should we have wrought to perfection as we have done—aerostation?

At the moment when victory has crowned our efforts, when a wise constitution has fixed the lot of France, when talent is honoured there and called to serve the country; at the moment above all when new schools are arising in the departments and are going to spread education and make the need of it felt on every hand, the authors of the Annales de Chimie believe that the need is pressing that they should continue their work. Their aim will be to carry the torch of science into all the workshops; to introduce new processes; to describe the arts less known or even entirely unused in France, to improve vicious practices; to rectify the errors still too numerous in many manufactures; to give the means of employing in useful preparations a crowd of substances hitherto too much neglected or even allowed to be lost; to disperse the secrecy of the workshops often deceptive, and their charlatanism always perfidious; to establish the clearest theories of the most obscure operations; to direct the steps almost always hesitating and uncertain of the workman; to destroy mystery and to repel fraud; in a word, to employ one of the most exact sciences in the multiplication of all the objects of national industry. Without neglecting philosophical

chemistry they will apply themselves specially to industrial chemistry, to that which creates, which illuminates and which brings to perfection the arts. They will not repulse brilliant and ingenious theories; but they will above all present their useful applications. It is to artists, to manufacturers and to intelligent artisans, to enlightened and honourable business men, for whom they particularly destine this work. Scientific men and philosophers will find there at the same time all the progress of physics and the advances of the human reason. It is obvious that in improving the arts among a great people, one improves at the same time the reason of man.

It is not necessary to say that we have combined all possible means to join to the discoveries of the French those which have been made in all the other nations in which chemistry and the chemical arts have been cultivated with success, and above all in Germany, in Spain, in Holland, in Italy and in England. The authors of the Annales de Chimie, having resumed their work, propose to unite in two volumes which will form the nineteenth and twentieth of the collection, the principal discoveries made and most remarkable work in Chemistry done in France from the month of September, 1793 to the month of January, 1797.

The contents of the volume to which these remarks form the preface were:

1. A notice to workers in iron on the fabrication of steel in which the physical and chemical properties of iron and steel are described and the methods of its production in England and elsewhere are given.

2. Then follows a description of the methods of fabrication of armes blanches at Klingenthal in Alsace with details of the manufacture of sabres and bayonets, ramrods, etc.

Then comes a report by Pelleher and others on various methods of obtaining soda from common salt, first of which is that of citizen Leblanc, presented by him with a noble devotion to the public good.

3. Memoir on the means of multiplying the fabrication of potash in France.

Instructions for obtaining paper by working up printed or written sheets.

9. Report on the manufacture of soap.

10. Extract from a report on attempts made at Romilli to separate the copper from bell metal.

11. Instructions as to the new Republican weights and measures.

12. On the extraordinary production of saltpetre in France during years 2 and 3 of the Republic.

13. Test on a grand scale made in the Russian army on the purification of water by powdered charcoal.

In these words the infant Republic made its confession of scientific faith. The position of the British Empire to-day resembles in some respects that of the French republic at that time. Against her were arrayed the trained armies of Austria and Prussia and she was forced to strain every nerve to improvise an army, to arm it, train it and provide it with munitions. If we, like revolutionary France, hope to rise triumphant from the crisis in which we now find

ourselves, we must, like her, call to our aid organized science. Scientific men our race has produced in abundance and these of the highest eminence, whose contributions to science, pure and applied, have been of the first importance. But of organization in scientific matters we have lagged behind and in particular we have been outdistanced by our enemies, the Germans.

There is no need to emphasize this. It has been dinned in our ears by friend and foe alike, but it must be insisted on that our inferiority in the application of science to industry, where there has been failure, has not been due to lack of genius or to lack of knowledge, but to other causes, partly educational, partly economical and partly political.

The raison d'étre of a university is to see to it that there may never be wanting a due succession of persons duly qualified for the public service.

The English idea of public service is the church, the bar and parliament, and the university ideal training has been the training that will qualify a man for success in those walks,—in short the power of speaking or writing convincingly.

In Germany where the power of popular assemblies was a negligible quantity the university ideal was quite another. In Germany men looked for success, not from the pleasure of a mob, whether that mob was called a jury, a congregation, or a parliament, but from the approval of their superiors, from experts, that is such as judges and heads of departments. Under these circumstances the key to success is efficiency, ability to do things, not fluency in talking about them. Efficiency then has been the ideal of the German universities.

Now in a very large number of cases the proprietors and directors of the German industrial establishments had been educated in one of these universities and when they required scientific advice they naturally looked to a member of the university for this advice and more than this, their education enabled them to appreciate this advice when it was given. They and their scientific advisors had the same point of view. They could understand each other's reasoning and appreciate each other's mental attitude. To this sympathy between the business manager and the scientific expert in his employ is to be attributed in a very large measure the successful application of science to agriculture in Germany.

What can we in this University do to promote and foster such a sympathy between the laboratory and the workshop, between the technical graduate and the foreman and superintendent?

First, we must give our students the best possible grounding in pure science and secondly, we must shew them the way to find out new things for themselves.

The University must, like a parent bird, nourish her brood by an abundant supply of suitable food, industriously gathered, selected and, if necessary, predigested, but when the nestlings are ready for flight she must guide and exercise by precept and example their unaccustomed wings till they are ready to shift for themselves

and their wings are strong and fit for their bold and adventurous flight into the unknown.

The Faculty of Applied Science and Engineering of the University of Toronto can point with pride to the work of its graduates and to the positions they have won in the Province and outside it as testimony that they have in the past been not unfaithful to the trust which the Province has reposed in it. But we feel that this is no time to rest upon our laurels. If we are to rise to the supreme demands of the present crisis and to its unique opportunities we must take some definite step forward in the direction of the encouragement and organization of industrial research. It appears to many of us that the most hopeful course in our immediate future would be the foundation of a School of Engineering Research, properly equipped, properly supported and directed by those among us who have shown themselves capable of leadership in this direction.

It is to be hoped that some such scheme will commend itself to the authorities for immediate adoption.

RETIRING PRESIDENT'S ADDRESS

Gentlemen,—As retiring president of the Engineering Society, I wish to thank you for your hearty co-operation and support during this past year. It has been a year without parallel in the history of the School, as also it has been in the world at large. You have stood by the executive, and rallied around us with the School spirit in a way that has never before been equalled.

Our meetings this year, in spite of greatly decreased attendance at the School, were successful throughout. They comprised the addresses given by A. H. Harkness, '95, on St. Andrew's "Movable Dam;" J. A. D. McCurdy, '07, "Aviation;" Lieut. (Prof.) T. R. Loudon, '05, "Military Engineering;" D. A. Molitor, C.E., "Surveying as Taught at Cornell University;" Lieut. M. B. Watson '10, of the Royal Engineers, on leave from France, who gave us a vivid account of engineer's work at the front.

The Annual Dinner held on February 4th, was one of the most successful functions ever held at the School and it was unique in every regard. One outstanding feature was the hearty support which you undergraduates gave the executive, probably for the reason that it was the last opportunity which many of us would have to be present at such an occasion. The dinner was also a success financially, and this will, I hope, form a precedent for the years to come.

* * *

Your thanks, gentlemen, are due to the Faculty for the deep interest taken by them in the Engineering Society, particularly to Dean Ellis, to a committee composed of Prof. H. E. T. Haultain, Prof. P. Gillespie, Prof. J. W. Bain and Prof. W. H. Price, appointed by the Council to aid the Society when we were in difficulty; and to Prof. C. H. C. Wright. These gentlemen have given time and

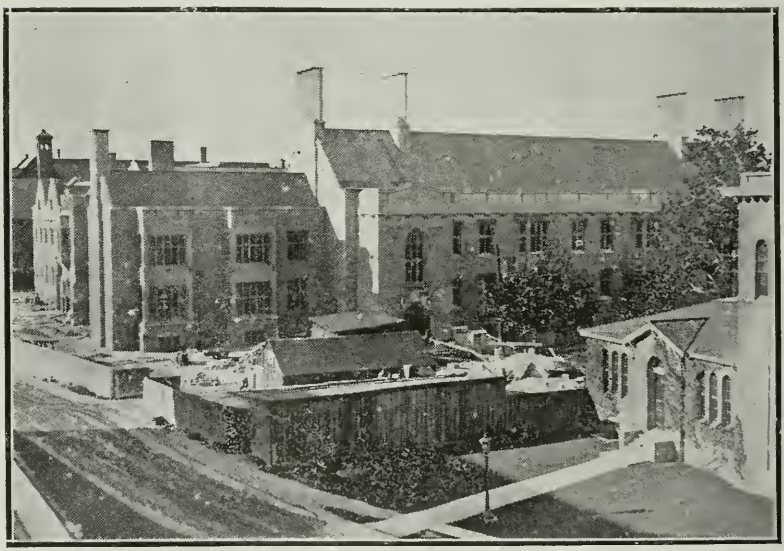
thought, and invaluable assistance in the interests of the Society, and our debt to them is great.

We are also greatly indebted to Mr. J. L. Ross of this city, a past president of the Literary Society. At a time when the affairs of the Engineering Society demanded the most careful handling, Mr. Ross gave most generously of his time and advice in legal matters without any charge whatsoever.

Your executive committee has been an able and strong one. They have worked hard and to them belongs the credit for what may have been accomplished this year. In particular may I mention W. B. Honeywell, to whom as interim president, is due your sincerest appreciation. Through the efforts of Mr. Honeywell and the other members of the executive relations of the Society to its creditors have been placed upon a satisfactory basis.

It is a pleasure on your behalf to welcome Mr. Banigan, as president-elect for the coming year. You have conferred upon him the highest honor in the gift of the undergraduate body of this Faculty. The responsibilities of this office are great and I hope that the high standards set by his predecessors may be even eclipsed in the coming year. I congratulate you on your choice of a president and executive committee.

W. Leslie Dobbin.



Hart House Nearing Completion

APPLIED SCIENCE

INCORPORATED WITH

Transactions of the University of Toronto Engineering Society

DEVOTED TO THE INTERESTS OF ENGINEERING, ARCHITECTURE AND APPLIED CHEMISTRY AT THE UNIVERSITY OF TORONTO

Published by the University of Toronto Engineering Society

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ENGINEERING SOCIETY AFFAIRS IN 1915-16

During the past year the Engineering Society has passed through a severe financial crisis. In July, 1915, Mr. R. G. Lye, who had been appointed secretary in April, was compelled to approach the graduates with the request for a loan of $500 to meet pressing obligations. A committee of graduates consisting of Messrs. E. W. Oliver, W. A. Bucke, W. B. Russel and H. E. T. Haultain undertook to secure the desired sum which was raised in the form of notes in Toronto, Montreal, Ottawa, Cobalt, Porcupine and New York. The necessary payments to creditors were duly made, and by October the notes given by the graduates had been entirely redeemed.

The financial condition of the Society obviously needed the most careful scrutiny, and after an audit had been made, the following facts became evident. The monthly issues of Applied Science had for some time past been published at a loss. This deficit was partly due to a falling off in advertisements as a result of the war, and partly to the fact that less than 50% of the graduates had paid their annual subscription.

Another important item on the balance sheet was "stock on hand." An inventory showed that some of the stock was very slow selling, an accumulated legacy in fact from several previous years.

Since 1907 a graduate had been employed by the Society as a permanent paid secretary and editor of Applied Science. During the years when the attendance was large the receipts from fees, the profits of the supply department, and the income from advertisements had been sufficient to appear to justify the payment of a salary. In 1915 the attendance had fallen and was still falling off steadily owing to the war and it became evident that the Society could no longer afford to carry on its business by the aid of a salaried official.

The above facts, together with the pressure of the creditors, led to a complete reorganization of the business methods of the Society. Under the expert guidance of Mr. J. L. Ross of the legal firm of Messrs. Ross & Holmsted, Toronto, the financial statement of the Society was laid before the chief creditors, and a working agreement was arranged by which the sums owing them were to be reduced pro rata as rapidly as possible, and some of the slow-selling stock was to be taken back by the creditors. Special efforts were made to decrease the amount of other dead stock, which met with considerable success.

The paid secretary resigned early in the session, and has not been replaced. The business has been carried on without loss of efficiency by the executive committee, with the aid of an assistant, Miss Dunlop, who assists in selling the goods and attends to most of the clerical work.

The publication of Applied Science was stopped in August, 1915. The present issue is the only one which it is intended to publish until after the war.

Owing to the resignation of the president at the beginning of the session, the vice-president, W. B. Honeywell shouldered the responsibilities during this difficult transition period. At a meeting of the Society held on November 17, 1915, W. L. Dobbin was elected president by acclamation. The cares of the office during the session have been particularly onerous and called for constant, unselfish effort. The affairs of the Society are now on a smooth running and efficient basis.

Communications from the Engineering Alumni Associations of Toronto and Ottawa have been received and are printed in this issue.

In Montreal there is a Toike Oike Club. In Cobalt, Haileybury, New Liskeard and Porcupine there is the Temiskaming Engineering Alumni Association. Both of these are alive and active. In New York there are a few ever interested and ever active graduates. In Pittsburg, Winnipeg, Vancouver there are or there have been recently active Engineering Alumni Associations. We are told that at one time in recent years there were twelve or thirteen organized associations. If there had been a central organization not controlling, but co-operating with branches, the benefit to the school, both graduates and under-gradutaes, would be continuous.

ENGINEERING ALUMNI ASSOCIATION

Doubtless, many of the graduates of the School of Practical Science and the Faculty of Applied Science are not aware that such an organization as "The Engineering Alumni Association of the University of Toronto" exists; therefore, the Toronto Executive Committee welcomes this excellent opportunity of acquainting such graduates with the fact that there is in Toronto an active Alumni Association. The following account will give an idea of the organization and we hope it will stimulate the dormant interest of some graduates in "School" affairs so that they will line up behind a big effort to increase its sphere of usefulness. With the co-operation of the graduates, a strong organization will be developed.

Early in the nineties an Alumni Association had been formed but it had little or no active life and before long ceased to exist even in name.

In the year 1909 some active graduates realized that, in order to maintain the prestige of the graduates, some organization must be formed through which they could express their respective views on matters of vital interest to the welfare of the school. Consequently, a general meeting of the graduates was called and an executive committee elected. This committee prepared a set of by-laws, which were adopted at the next annual meeting. The first two clauses are as follows:—

Name. The name of this Association shall be the Engineering Alumni Association of the University of Toronto.

Objects. (a) To endeavor to increase the interest of the graduate body in University affairs looking to the still greater efficiency of the Faculty of Applied Science and Engineering.

(b) To hold frequent meetings for the promotion of social intercourse amongst the graduates, and for the discussion of matters affecting the interests of this Faculty and the graduate body.

(c) To institute the necessary representations to carry into effect the recommendations of the Association.

Two other clauses read:—

All business meetings of both the Association and of the Executive Committee shall be held in Toronto.

An annual fee of one dollar shall be requested from each member to provide funds for the petty expenses of the Association.

The Engineering Alumni Association of the University of Toronto thought it wise to extend their activities and undertook to create Research Fellowships. Among other clauses by-laws governing these fellowships contained the following:—

These fellowships shall be called "Research Fellowships in the Faculty of Applied Science and Engineering, University of Toronto."

The value of these fellowships shall be five hundred dollars ($500.00).

These fellowships shall be open to any graduate of the School of Practical Science and of the Faculty of Applied Science and Engineering of the University of Toronto; also to anyone who has

attended a regular course for two years in this Faculty and subsequently by following his profession has attained a position of importance in his field of work.

Each fellow shall devote at least 26 weeks' work to his research.

It is intended that the Research Work during the life of the fellowship shall be conducted in the laboratories of the Faculty of Applied Science and Engineering, University of Toronto, and under the supervision and guidance of the professor at the head of the department involved.

On the completion of his work under this fellowship, the holder shall make a written report to the executive committee of the Engineering Alumni Association outlining the course of his Research Work and the results obtained; provided, however, that if on representation to the Executive Committee, it shall be deemed advisable to withhold such information for a time, permission so to do may be granted.

Since the inauguration of the Research Fellowship, the fellowships have been awarded to: M. R. Shaw, 1909, Chemistry, awarded in 1912, and W. P. Dobson, 1910, Investigation of Disturbances in High Tension Transmission Systems, awarded in 1912, renewed for two additional terms. Owing to the lack of space, we are unable to publish the results of these scholarships, but suffice it to say that the executive feels that they have been amply repaid for the effort which they put forth in securing sufficient funds to carry on this work.

We also wish to take this opportunity of thanking the graduates who subscribed to this worthy object. It is unfortunate that, owing to the present conditions, we will not be able to carry on this valuable work, but we live in anticipation of increased activities after the restoration of normal conditions. In the interim, we hope that the graduates will not forget and will be ready to contribute when called upon

During this year, the Toronto Executive Committee are endeavoring to affect a reorganization of the whole of the association so that branches will work in harmony with and through the organization located in Toronto. A new set of by-laws is being prepared and they will be submitted to the different branches for discussion. If we are successful in this venture we feel that a great deal will have been accomplished, and the bright future of the organization will be ensured.

"W. R. Worthington,"
President, Toronto Branch.

OTTAWA ALUMNI ASSOCIATION

For many years Ottawa "School" men have felt that there should be some recognized relationship between the Faculty of the "School" and the graduate body, and also between the graduates themselves resident in various centres. We have felt that there is a great work to do in Ottawa for the "School" in advancing the interests of "School" men in the various departments of the Govern-

ment service, in assisting and advising the recent graduates regarding opportunities in the Government service, and in helping undergraduates to find suitable employment during the summer vacation.

A few years ago, a few graduates of the "School" resident in Toronto organized what was known as the Engineering Alumni Association of the University of Toronto. A constitution and by-laws were adopted which would indicate that the Association was intended to comprise all graduates of the "School." This Association has done good work in the interests of the "School," and has, for instance, conceived and carried out a scheme of research from which it is understood excellent results have been obtained.

Quite independent of this Association, "School" organizations in various centres have been formed without any reference whatever to it. For instance, Ottawa "School" men have formed the Ottawa Branch of the Engineering Alumni Association of the University of Toronto. A constitution and by-laws have been adopted which take no cognizance of the original Association in Toronto.

The present situation, therefore, is that there are "School" organizations of various descriptions in Toronto, Ottawa, Montreal, Pittsburgh, Winnipeg, Calgary, Vancouver, which are not correlated in any way. In union there is strength, and the Ottawa "School" men feel that the graduates of the "School" will never be able to make their influence felt for the best interests of the old "School" until the various "School" alumni organizations are properly correlated.

In my opinion this correlation can be best realized by having branches of the University of Toronto Engineering Alumni Association formed throughout the various centres. Provision should be made for the relationship of these branches with the Toronto organization and with one another. Just what relationship this should be may be somewhat difficult at the present stage to work out, but a satisfactory solution can no doubt be had if the problem is given any thought or consideration. In so far as Ottawa "School" men are concerned, there need be no doubt about their heartiest co-operation and active assistance in any movement that will advance the interests of the old "School," its Faculty, its graduates and its undergraduates.

"J. B. Challies,"
Secretary, Engineering Alumni Association,
Ottawa Branch.

SCHOOL WELL REPRESENTED IN INTER-COLLEGE DEBATING

The second year of School's entry into the Inter-College Debating Union showed a great improvement over last year. This year we defeated Knox College, in the first round. Mr. L. R. Shoebottom, '17, and Mr. V. S. C. McClenaghan, '18, were the successful debaters.

In the next round we drew against Wycliffe College and were defeated by a narrow margin. The judges giving the decision

stated that while the School debaters were better on matter they lost on style. This goes to show the necessity of a course of public speaking in this institution before our men can hope to cope on equal terms with men from other colleges where such a course is in force. Not only for debating would such a course be a decided benefit for School men, but it is now recognized that a successful engineer, no matter in what branch he specializes, is under a great handicap if he has not the ability to speak on his feet.

Mr. H. L. McClelland, '16, and Mr. V. S. C. McClenaghan, '18, represented the School in the second debate. Wycliffe College finally won the Kerr Shield, the debating trophy of the I.C.D.U.

Mr. W. B. Honeywell, '17, was the School representative on the Inter-College Debating Union and was elected vice-president.

ATHLETICS

Following the precedent established in 1914-15, no teams represented the university against outside teams last year, attention being confined to the inter-faculty contests. In rugby, Junior School won the Mulock Cup from Victoria, but lost at soccer. Both junior and senior teams won their respective groups in hockey, but each lost out to the two Dental teams in the semi-finals. The sophomores defeated the freshmen in their annual fall struggle, and our track team captured third place at the inter-faculty field day sports. On another page is shown Hart House, the new students' building, as it appeared on June 22. It is expected that the building will be opened next winter.

A PSALM OF LIFE AT S. P. S.

A. T. C. McMaster, '01

[Few of us know the history of our Psalm of Life, or the original wording of it. Prof. Price tells us that Mr. McMaster of his year was the one whose poetic skill created it. Mr. McMaster, who is now an engineer and contractor in Toronto, has consented to give us the story.—Editor].

The Original Words

1. Stand up! Stand up for the Science Faculty!
   With the Arts and the Meds they form a trinity.
   Then shout you chaps for the S.P.S.,
   Whose motto is meekness and peacefulness.

2. The first-year man when he comes up to the School
   Gazes with awe on a two-foot rule.
   Then shout——

3. The second-year man has learned about the tap;
   He sizes up the freshman with an eye to a scrap.
   Then shout——

4. The third-year man'd rather fall down a mine
Than go to the depths of Constructive Design.
Then shout——

5. The fourth-year man comes back to have a fling;
He bums round the lab and he "doesn't do a thing."
Then shout——

6. Now we hope this song has touched your hearts,
And you won't consign us to warmer parts.
For we've shouted this psalm for the S.P.S.,
Whose motto is meekness and peacefulness.

This is the song we sang when welcoming the then Duke of York, our present King George V, to old Varsity. I am informed that the blame for it has been laid upon my shoulders. I must admit some of it, but will tell you the whole story and let you judge for yourselves.

The Convocation at which the Duke received his honorary degree, as he passed through Toronto on his grand tour of the British Empire in 1901-02, was held in the East Hall of the main building. The ground floor was reserved for the invited guests, and the small gallery was given over to the students. This necessitated the choice of just two or three representative members of each class. Among those chosen from S. P. S. was the writer, then in his fourth year.

In order that things might run smoothly, it was decided to have some rehearsals of college yells and songs in one of the class rooms of the main building. It then transpired that all the faculties and affiliated colleges, but S.P.S., had special songs of their own. Whereupon one of the professors present, recognizing in me one who formerly had followed him along arduous trails in ancient literature, turned his sarcastic rhetoric on me and questioned why the School had never been able to produce or even adopt anything worth singing. Now in those days criticism from any outsider was strenuously resented, for, when not busy with lectures or drafting or lab work, we were working off our pent-up energies in winning all interfaculty cups, or turning things inside out with our famous scraps. The result of that criticism, therefore, was to get my Irish up, and D. L. H. Forbes[1] and M. V. Sauer[2] and I spent the evening doping out the Psalm of Life at S.P.S. to the then popular air of "The Dutch Companee."

The next morning I submitted the Psalm to our Dean (the late Dean Galbraith) to make sure that he had no objection to any of the sentiments expressed, had it typewritten, and placed in the hands of the vocal committee so that when the next rehearsal took place, either that afternoon or the following one, there was no longer any cause to be ashamed of a faculty unhymned and unsung.

It has been a surprise to me to find such a hasty effort still

1. Chief Construction Engineer, Chile Exploration Co., Chuquicamata, Chile, South America.
2. With the Greater Winnipeg Water District.

clinging to the old School. I believe the real cause has lain in the deep irony of that last line of the refrain:—"Whose motto is meekness and peacefulness." I well remember the glee with which Max Sauer and I greeted this masterpiece when suggested by Dave Forbes. And possibly His Royal Highness, all unconscious of its irony, may have been comparing this sentiment with some of the truculent utterances of the War Lord against whose mailed fist so many of our School men are now opposing their best efforts of body and mind.

HOW CANADIANS JOIN THE AVIATION CORPS

Canadian applicants for aviation training have but the British service to consider as, so far, the Canadian Government has not seen fit to establish an Aviation Corps, distinctively Canadian.

The British Air Service is divided into two sections, the Royal Naval Air Service and the Military Wing of the Royal Flying Corps. For both of these services there is a very rigid examination for physical condition and an even more rigid one in regard to the eye sight. An aviator must have eye sight of the very highest to enable him to distinguish objects at a long distance and to easily and quickly determine the color of the various objects which he may see during his flights.

The question of age also enters into consideration for both branches of the service. For the Navy, applicants must be from 19 to 25 years of age and for the Army up to 30 years. The Navy is, perhaps, more rigid as to the question of age, as they ask for a copy of the birth certificate of the applicant. Applications are made to Admiral Kingsmill of the Department of the Naval Service at Ottawa and in every case the applicant has to meet him personally, in addition to the production of a number of certificates of good character, etc.

The applicant having passed these, he must needs qualify for his pilot's certificate and the majority of them have done so at the aviation school operated by Curtiss Aeroplanes & Motors, Limited, which is situated at the Rifle Ranges at Long Branch. The cost of such course is four hundred dollars, but of this $375 is refunded by the British Government upon the aviator successfully passing the further tests that are imposed in England, namely, cross country flying. This year the Canadian Government is making a grant of one hundred dollars for maintenance to each candidate who successfully gets his pilot's certificate.

The course of instruction in flying is simply the handling of a machine. The first trip is usually a "joy ride" to give the candidate some idea of what the machine can do and get him accustomed to its operation. In succeeding flights the candidate is gradually given control of the machine. These machines are equipped with dual control so that this can easily be accomplished, the instructor being ready at any time to check any error made by the pupil. Gradually the pupil becomes proficient in handling the machine in the air. Then there follows a more tedious section of the instruction,

that of enabling him to properly take the machine off the land and bring it down safely without the destruction of the machine. This is the hardest part of the instruction, because the pupil has to learn to judge the distance and speed of the machine.

After a course of five or six weeks of instruction the day of testing arrives and under the oversight of some representative of the Royal Aero Club of Great Britain the candidate will take the machine out alone and be called upon to make two series of figure eights, from one of which he is to make a landing within a certain distance of a prearranged mark. The final test is to ascend to a height of about 500 feet, then cut off his motor, glide down, landing within a certain distance of a mark. Having accomplished this successfully a report is made at once to the Royal Aero Club and the candidate is entitled to receive his certificate, which he has to obtain personally in England.

Immediately following the successful tests the information is forwarded to Ottawa and the candidate is practically under orders and is sent to England within a week or ten days.

On reporting there the additional training is at once taken up. This includes a series of lectures on aeroplane and motor construction, wireless, signalling of all kinds, machine gun work and bomb dropping. Further, the pupil has to become proficient in handling a certain number of other makes of machines. He is also called upon to do cross country flying to a distance of from 40 to 60 miles, make a report upon what he has seen, and draw a map of the district over which he flew. When he has done this successfully, he obtains his "ticket" and becomes a full fledged pilot, either military or naval, and is entitled to the wings, the badge which shows his proficiency. He then may be sent out as an instructor at one of the schools or may go into active service.

Among the many who have gone through the Curtiss school and are now in England or France are the following School men: D. G. Joy, G. A. Gooderham, C. N. Geale, G. R. S. Fleming, G. K. Williams, R. D. Delemere, C. G. Hewson, J. Robinson, E. R. Grange, K. Waugh, A. G. Knight, G. G. MacLennan, W. R. Da Costa, F. C. Birtle, G. S. Gray, R. H. James, N. C. Millman, R. E. A. Macbeth, H. A. Wood, W. M. Carlyle.

"OUR RESPONSE TO THE EMPIRE'S CALL"

Ever since war was declared, there has been a steady stream of School men answering the call of King and Country. They are to be found in almost every unit and arm which Canada has contributed or is contributing to the cause. The graduates from coast to coast have flocked to the flag.

Many graduates, as well as under-graduates, were in the first Canadian Contingent; more were in the second, while a host of others are enlisting and getting ready.

To-day we honour the names of the following nine of our number who have given their lives for us and our country: **Andrews, F. C., '14; Eardley-Wilmot, F. L., '17; Helliwell, J. G., '10;**

Hughes, C., '09; Klotz, H. N., '09; Lawless, N., '11; Revell, G. E., '99; Taylor, G. B., '14; Ryerson, G. C., '05.

Many have received well merited promotion, others have received special mention in order, while not a few have won military honours. The Chief Intelligence Officer of the First Contingent was Major C. H. Mitchell, '92, of the Corps of Guides, now Lieut.-Colonel on the General Headquarters Staff of the Canadian Army Corps in France. His work has been mentioned many times in despatches, for which he has been awarded the D.S.O., by the King and La Legion d' Honneur Croix d' Officier by the President of the French Republic. The Intelligence Officer of the Second Contingent was again a School man, Major J. L. R. Parsons, '01. Like the first contingent, this too contained many School men in every capacity, as may readily be seen in the published list, which follows.

In many of the units, "School" men have been of recognized service on account of their special training and experience, such as mechanical men in the transports, the electrical in the Signalling Corps, the civil, mining and architectural in the Engineers, etc. Aviation has offered alluring inducements to many, for while McCurdy, '07, Riddell, '04, and others, are busy building machines in Toronto, G. K. Williams, '10, is mechanical superintendent of the Air Training School at Detling in Kent. A reference to the list will show many others connected with this service. School men have thus contributed largely to this, the newest arm of the service.

The Second Field Company of Canadian Engineers were asked to supply a Field Company of War Strength (217) for the First Contingent and in short order Captain T. C. Irving, '06, was on his way to Valcartier with his company fully recruited to strength. With him he took many School men, as officers, non-commissioned officers and sappers. When they sailed for England Irving was second in command. Before reaching France, however (on account of the illness of the major) he was given command of the company. Very shortly afterwards in recognition of his excellent work, he was made major. The good work this company of engineers has done and is doing along the firing line of the Canadian Battle Front in France, is evident from the official despatches of both London and Paris, as well as by the many awards of merit from Britain and France.

Lieutenant now Captain H. F. H. Hertzberg, '07, was rewarded for his brilliant work, with the Military Cross. Sergeant C. B. Ferris received the D.C.M. and the Croix de Guerre.

Sapper now Lieutenant C. P. Cotton, '15, has been awarded the Russian Cross of St. George; and Sergeant W. H. B. Bevan, '05, was also awarded the D.C.M. The official report, as published in the Toronto press, contains the following:

"SERGEANT C. B. FERRIS, Second Engineers, for advancing alone under extremely heavy fire and making a valuable report, after being shot in the lungs."

"SERGEANT W. H. B. BEVAN, Second Engineers, checked

the native troops retiring in disorder and inspired all ranks with his fine example."

While the Second Field Company of Engineers was in England, Corporal M. B. Watson, '10, met with an accident (rolled down an embankment with a motor truck) and as a result was in the hospital when they moved over to France. Later on, however, he was given a commission in the Royal Engineers and ever since has been acting as a lieutenant with an Army Corps Troop in France. His visit (on leave) to the Engineering Society, a short time ago, was a treat, and all who were fortunate enough to hear him will remember the occasion, as one of the features in this college year.

The Machine Gun Section of many of the Canadian Battalions, the Eaton Machine Gun Battery, as well as a large number of the batteries of artillery, contained School men in different capacities.

To-day the attendance at the Old School is so greatly reduced that if the roll were called at a muster parade, not more than two hundred would answer to their names. The ranks of the staff are likewise thinner, as the call keeps up, for they, too, are "doing their bit." Many of those left are doing extra duties, in order to let their confreres off for military service. Professor McConnell, is now captain and adjutant of the 116th Battalion, C.E.F.; Professor Cockburn with the rank of captain, has command of "A" company in the 170th Battalion; Mr. J. S. Galbraith, is assistant adjutant of the 123rd Battalion; Mr. H. O. Merriman, with the rank of flight lieutenant, is with the Royal Naval Air Squadron; Mr. G. H. Hally is a gunner with the 26th Battery, and Mr. A. L. Steele is with the Canadian Army Service Corps.

Professor C. R. Young and Mr. H. H. Madill, are on the Cadre of the School of Instruction for Number 2 Division, while Professor T. R. Loudon has charge of the Instruction in Engineering to the C.E.F.'s Battalions for Number 2 Division. Major A. D. LePan is adjutant with the School of Instruction in the same division.

It is safe to say that there will be a great representation from the Faculty of Applied Science in the University Overseas units, just authorized, viz., the University of Toronto Officers' Training Company and the University of Toronto Battery of Artillery.

At the recent Garrison Artillery examination held in England, two School men, E. B. Allan, '16, and R. T. C. Hoidge, '16, stood first and second respectively in the examination for second lieutenants.

The following list of School men on active service is as complete as the Engineering Society has been able to compile and any corrections or additions will be welcomed.

That so many of the undergraduates of last session and this have been able to acquit themselves so efficiently, is largely due to the enthusiastic manner in which they have availed themselves of the opportunities offered by the University of Toronto Contingent of the Canadian Officers' Training Corps, which was established shortly after the outbreak of hostilities, by the Honourable Sir Sam Hughes, Minister of Militia, at the request of President Falconer.

ON ACTIVE SERVICE

† Killed in action. ‡ Wounded. ° Prisoner of war. * Honors.

Abendana, E. M., Lieut., '14; Canadian Engineers.
Adlard, L. S., Lieut., '15; Camp Lab. Unit, 2nd Div.
Affleck, J. K., '18; 67th O.S. Bty., C.F.A.
Affleck, R. D., '18; 67th O.S. Bty., C.F.A.
Aggett, W. H., Gnr., '17; 25th Bty, C.F.A.
Allen, Carl W., Capt., '01; 2nd Canadian Pioneers Bn.
Allan, E. B., 2nd Lieut., '16; Imperial Army.
Allan, F. R., Pte., '18; 35th Bn., Mach. Gun Sec.
Allan, L. B., '11, Course at S.O.I.
‡Alport, F., Lieut., '06; 6th Field Co., C.E.
Amsden, W. G., Lieut., '10; 220th Bn.
Anderson, A. S., Pte., '13; 2nd University Co., P.P.C.L.I.
Anderson, C. C., Sapper, '16; No. 3 Stationary Hospital.
Anderson, F. J., Lieut., '07; 98th Bn.
Anderson, A. C., '15; 2nd Univ. Co., P.P.C.L.I.
Anderson, R. M., Lieut., '08; Div. Cyclist Depot.
†Andrews, F. C., Lieut., '14; Imperial Army.
Andrew, W. B., Lieut., '17; 33rd Bn.
Angus, J. C., Sapper, '18; Divisional Signal Co.
Archer, E. G., Lieut., '11; Course at Kingston.
Armstrong, T. E., Driver, '16; 21st Bty., 6th Howitzer Bde.
Armstrong, W. D., Sapper, '17; 6th Field Co., C.E.
Arthur, R. M., Gnr., '15; 25th Bty., C.F.A.
Austin, F. D., L.-Cpl., '15; 2nd Signal Co., R. C. Engineers.
Avery, C. R., Gnr., '13; 4th Bde., 13th Bty.
Aykroyd, G. C., Pte., '18; 40th Bty., C.F.A.

Baird, W. J., Cpl., '10; Divisional Train, C.A.S.C.
Baldwin, F. W., Lieut., '06; Royal Flying Corps.
Baldwin, L. C. M., Lieut., '13; 9th South Lancashire Regt.
Ball, O. V., Gnr., '17; 47th Bty.
Barbour, R. A., Lieut., '17; C.A.S.C.
Barnes, L. F., Lieut., '16; Imperial Army.
Bartlet, F. A., '15; 1st Contingent.
Bauer, W. R., Gnr., '17; 25th Bty., C.F.A.
Beacock, V. A., Pte., '15; 3rd University Co., P.P.C.L.I.
Beatty, F. W., Gnr., '13; 43rd Bty.
‡Bell, C. A., Lieut., '13; 2nd Field Co.
Bemrose, B. W., '16; 67th O.S. Bty., C.F.A.
Bennett, S. G., 2nd-Lieut., '14; Royal Engineers.
Berkeley, G. L., Capt., '11; Div'l Cycle Corps, O.C.
Betts, H. H., Lieut., '06; Ry. Transport, Boulogne.
Bevan, T. H. H., Lieut., '08; M. G. Sec., 86th Bn.
*Bevan, W. H. B., Cpl., '05; 2nd Field Co. (won D.C.M.)
Binns, P. V., Lieut., '14; 2nd Fd. Co., Canadian Engineers.
Binns, R. E., Lieut., '13; Royal Engineers.
Birchard, E. R., Sgt.-Major, '09; Eaton Bty.

Bishop, C. A., Lieut., '18; 220th Bn.
Bishop, W. A., Gnr., '17; 25th Bty, C.F.A.
Black, A. P., Pte., '15; St. John's Ambulance Hosp.
Blackstock, G. G., Lieut., '15; Imperial Army, General Burstall's Staff.
Blair, F. J., Lieut., '11; 198th Bn.
Booz, F. B., Pte., '18; 34th Bty.
Breen, J. M., Sapper, '18; Divisional Signal Co.
Breithaupt, J. E., '15; Course at S. of I.
Brereton, L. R., Sgt., '13; 2nd Troop Co., Can. Engrs.
Brock, W. M., Sapper, '11; Div'l Signal Co., C.E.
Brodie, W. M., Lieut., '95; Course at S. of I.
Brouse, E. D. G., Lieut., '15; C.A.S.C.
Brown, W. G., 2nd-Cpl., '16; 5th Field Co., C.E.
Bryant, G. F., Lieut., '18; Imperial Army.
Burden, H. J., Capt., '15; 75th Bn.
Burgess, J. R., '10; Canadian Engineers.
Burn, G. A. H., Pte., '17; Divisional Signal Co.
Burness, K. C., L-Cpl., '15; 2nd University Co., P.P.C.L.I.
Burton, C. E., '17; 67th O.S. Bty., C.F.A.
Burton, H. R., '18; Divisional Signal Co.
Burwash, N. A., Sapper, '03; 6th Fd. Co. C.E.
Bush, C. E., Lieut., '07; Div'l Cycle Corps.
Bussell, E. I., Lieut., '19; Course at P.S.I.
Byres, E. S., Gnr., '17; 25th Bty.

Cameron, O. L., Lieut., '13; 12th Rgt.
Campbell, F. W., Pte., '18; R.C.H.A.
Campbell, H. M., Lieut., '14; Spec. Service Squad, 1st Hussars. 2 C.E.F.
‡Campbell, P. G. C., Lieut., '15; R.F.C.
Campbell, J. J., Lieut., '14.
Campbell, J. J., '14; 67th O.S. Bty., C.F.A.
‡Campbell, W. C., Lieut., '05.
Canniff, C. M., Pte., '88; 74th Bn.
Carlyle, W. M., Lieut., '10 Royal Naval Flying Corps.
Carmichael, A. H., Lieut., '18; 180th Bn.
Carscallen, H. R., Lieut., '08; Canadian Engineers.
Carruthers, K. L., Lieut., '19; Imperial Army.
Carter, J. M., Gnr., '14; 34th Bty.
Catto, R. W., Lieut., '15; Royal Flying Corps.
Caudwell, N. S., Lieut., '10.
Cavers, J. P., Sgt., '16; Machine Gun Section, C.E.F.
Cawley, H. E., Lieut., '09; 7th Bty., 3rd Bde.
Chamberlain, K. H., Sgt., '18; H. Q. Base Staff.
Chambers, E. V., Lieut., '14; 92nd Bn., Machine Gun Section.
Chantler, H. M., Pte., '19; Div'l Cycle Corps.
Chapman, J. R., Gnr., '16; 49th Bty.
Chavignaud, L. G., '15; 19th Bn.
Cheney, S. K., Gnr., '16; 25th Bty., 7th Bde.
Chesnut, A. W., Pte., '10; 4th Univ. Co., P.P.C.L.I.

‡Chesnut, E. F., Cpl., '11; 19th Bn., No. 1 Co.
Clarke, F. F., Lt.-Col., '03; 127th Bn. O.C.
Clark, H. S., Lieut., '10; 36th Bn.
Clarkson, G. E., Lieut., '13; 123rd Bn.
Coatsworth, C. P., Lieut., '18; Pioneers Bn.
Cockburn, G. A., Lieut., '15; 43rd How. Bty., C.F.A.
Cockburn, J. R., Capt., '01; 170th Bn.
Cockburn, R. M., Lieut., '15; 116th Bn.
‡Code, A. G., Sapper, '10; Div. Engineers, 1st C.E.F.
Connor, R. A., Lieut., '18; Imperial Army.
Cooch, H. A., Q.M., '09; 216th Bn.
°Cory, R. Y., Capt., '08; 15th Bn.
*Cotton, C. P., Lieut., '15; 2nd Bde., C.F.A. (Cross of St. George)
Coulthard, R. W., Major, '99; No. 2 Tunnelling Corps.
Craig, J. H., Capt., '10; Adj. 127th Bn.
Craigie, D. E., Sapper, '18; Div'l Signal Co.
Crane, J. W., Lieut., '18; 216th Bn.
Crawford, A. W., Cpl., '14; Signal Co., C.E.
Cross, R. A., Pte., '17; 2nd Univ. Co., P.P.C.L.I.
Crowell, C. R., Lieut., '19; Imperial Army.
Crysler, R. A., Gnr., '17; 47th Bty.
Curtis, W. T., Lieut., '13; 2nd Canadian Pioneers Bn.
Crowe, H. L., '19; Royal Flying Corps.

Dalton, George F., Lieut., '14; Canadian Engineers.
Dingnam, H. M., '19; 67th O.S. Bty., C.F.A.
Dale, W. P., Sapper, '17; Divisional Signal Co.
DaCosta, W. R., Lieut., '15; Royal Flying Corps.
Dafoe, E. R., Gnr., '17; 25th Bty., C.F.A.
‡Daniel, N. H., Lieut., '15; Artillery.
Daniel, T. A., '16; 26th Bty., C.F.A.
‡Dashwood, G. R., '16; 13 Northumberland Fusiliers.
Dashwood, R., Lieut., '14; 13 Northumberland Fusiliers.
Davidson, G. P., Lieut., '15; Imperial Army.
Deacon, L. J., '18; Army Transport.
Dean, W. A., Lieut., '15; 198th Bn.
DeGruchy, P. C., '17; Field Ambulance.
Delamere, R. D., Lieut., '14; Royal Flying Corps.
Delaporte, A. V., Capt., '10; Hyd. Corps.
Devlin, H. K., Lieut., '18; 75th Bn.
Dickenson, M. E., Pte., '18; Div'l Ammunition Sub-Park.
Dobbin, W. L., Lieut., '16; Canadian Engineers.
Downey, G. A., Lieut., '15; 12th Bty., C.F.A.
Downie, R. W., , Sgt., '16; 2nd Field Co., C.E.
Downing, F. H., '11.
Drybrough, J., Pte., '19; 67th O.S. Bty., U. of T.
Duncan, J. M., Lieut., '10; H.M.S. Lion, R.N.
Durbrow, P. A., Gnr., '17; 26th Bty., C.F.A.
Dustan, E. B., Gnr., '17; 25th Bty., C.F.A.
Duggan, S. F., '18.

Eadie, L. F., L.-Cpl., '10; 75th Bn.
†Eardley-Wilmot, F. L., Lieut., '17; P.P.C.L.I.
Eastwood, J. H., Lieut., '16; 93rd Bn.
Eby, H., Pte., '17; 47th Bty., C.F.A.
Edmonds, C. W., Gnr., '16; 25th Bty., C.F.A.
Elliott, G. R., Lieut., '11; Div'l Cyclist Corps.
*†Ellis, S. D., Lieut., '14; Imperial Army (died after operation for appendicitis). (Awarded M.C.).
Evans, A. C., '15.

Farrelly, T. J., Sapper, '11; Div'l Signal Co.
Fasken, J. E., '18; 67th O.S. Bty., C.F.A.
Ferguson, D. G., Lieut., '14; 123rd Bn.
Ferguson, G. H., Capt., '05; Canadian Engineers.
‡**Ferris, C. B., Sgt., '13; 2nd Field Co., C.E. (D.C.M.; Croix de Guerre).
Firstbrook, J. H., Lieut., '18; Royal Flying Corp, (Naval Wing).
Fleming, G. O., Lieut., '14; 1st Construction Bn.
Fleming, G. R. S., Sub-Lieut., '07; Royal NavalAir Service.
†Fleming, J. S., Sgt., '14; 2nd Canadian Pioneers Bn.
Flint, C., Lieut., '08; C.P. Ry. Construction Corps.
Fowlds, E. S., Sapper, '13; 2nd Field Co.
Fraser, R. A., Lieut., '16; 37th Bn.
French, W. G., '15; Ry. Construction Corps.
Frid, H. P., '15; 86th M.G. Bn.
†Frogley, H. W., Corp., '11; 5th Field Co.
Fuller, C. H. R., Lieut., '14; 216 Bn.

Gage, C. E., Sgt., '16; Ammunition Column, 4th Bde.
Galbraith, J. S., Capt., '13; 123rd Bn., Asst. Adj.
Galbraith, R. D., Lieut., '15; 23rd Reserve Bn., C.E.F.
Gall, Hugh, Lieut., '10; 2nd Fd. Coy, Canadian Engineers.
Gardner, J. W., Lieut., '18; 177th Bn.
Gardner, R. T., L.-Cpl., '19; 53rd Bty.
Gardner, D. B., Lieut., '16; Canadian Engineers.
Garrow, A. B., Lieut., '07; 74th Bn.
Garvie, J. A., Lieut., '18; Imperial Army.
Geale, C. N., Flight Sub-Lieut., '15; Royal Naval Air Service.
Gemmell, K. S., Sapper, '18; Div'l Signal Corps.
German, D., '17; 4th Bde. Hdqts., C.F.A.
Gibson, F. R., Lieut., '17; Mechanical Transport.
Gibson, J. M., Capt., '10; 127th Bn.
Gilley, J. R., Lieut., '17; 234th Bn.
Gilley, E. R., Sapper, '17; Divisional Signal Co.
Gill, E. I., Lieut., '14; Course at Kingston.
Gillies, A., Lieut., '07; 186th Bn.
Givens, H. F., Lieut., '19; Imperial Army.
Glass, L. G., Sapper, '15; 4th Div'l Signal Co.
Glover, T. S., 2nd-Lieut., '17; 3rd Bn. King's Own Yorkshire Light Infantry.
Gooderham, G. A., Lieut., '15; R.F.C. (Naval Wing).

Gooderham, H. S., Lieut., '18; 20th Bn.
Gordon, R. V., '18; 88th Bn.
Gorrie, H. T., Lieut., '18; C.A.S.C.
Gouinlock, G. R., '18; Course at Kingston.
Gouinlock, R. W., Lieut., '14; 123rd Bn.
Graham, D. S., Lieut., '17; Div'l Cycle Corps.
Graham, T. S., Sapper, '15; Div. Signal Co.
Grange, E. R., Lieut., '15; R. F. C.
Grassett, H. A. M., Pte., '16; 3rd Bn.
Gray, A. G., Lieut., '13; 44th Reg.
‡Gray, A. J., Lieut., '13; 16th Bn.
Gray, G. S., Lieut., '15; Royal Flying Corps.
°Greene, E. A., Lieut., '11; 9th Bty., 3rd Bde.
°Greene, G. E. D., Lieut., '09; 3rd Bn.
Greene, P. W., Lieut., '06; 35th Bn.
Greey, Allan, Lieut., '09; 170th Bn.
Gzowski, J. S., Lieut., '09; 19th Bn.

Haas, M. S., Lieut., '15; 36th Bn.
Hadley, W. F., '16; No. 1 Div. Corp of Guides.
†Hagarty, D. G., Lieut., '16; 2nd Univ. Co., P.P.C.L.I.
Hague, R. D., Sapper, '08; No. 3 Co., Div'l Engineers.
Haldenby, E. W., Lieut., '17; 92nd Bn.
Hally, G. H., Gnr., '14; 26th Bty., C.F.A..
Hames, C. O. R., Sapper, '19; Div'l Signal Co.
Hanna, J. J., Sapper, '14; 1st Field Co., C.E.
Harcourt, R. M., Capt., '09; 35th Bn.
Harman, J. A., Sub-Ft. Lieut., '11; Royal Flying Corps.
‡Harris, R. W., 2nd Lieut., '15: R. E.
Harrison, R., Sapper, '18; Divisional Signal Co.
Harron, L. W., Lieut., '16; 204th Bn. (Signalling Officer).
Harrop, C. E., '17; 67th O.S. Bty., C.F.A.
Harvie, N. J., '10.
Hastings, C. E., Lieut., '16; C.A.S.C.
Hastings, M. B., '11; Course at Kingston.
Hawkey, R. R., Gnr., '17; 47th Bty.
Hayman, L. T., Lieut., '14; Course at P.S.I.
Heatley, A. H., Pte., '19; 5th Univ. Co. P.P.C.L.I.
*‡Heaton, H. A., Lieut., '15; Royal Lans. Regt. (Won M.C.).
†Helliwell, J. G., Capt., '10; 1st Bn.
Henderson, M. G., Gnr., '17; 47th Bty, C.F.A.
Henderson, T. D., Lieut., '04; Canadian Engineers.
Heron, J. B., Lieut., '04; 1st Const. Batt.
*‡Hertzberg, H. F. H., Capt., '07; 2nd Field Co., 3rd Bde. (Won M.C.)
Hewson, C. G., 2nd-Lieut., '17; Royal Flying Corps.
Hewson, R. R., Lieut., '15; Ry. Constr. Corps.
Hill, Gnr., 43rd Bty.
Hinch, E. F., '11; C.F.A.
Hoag, C. K., '17; Sig. Sec., 4th C.M.R.
Hoidge, R. T. C., 2nd-Lieut., '16; Imperial Army, R.G.A.

Holcroft, H. S., '00; No. 2 Tunnelling Co., Calgary.
Hopkins, C. H., Sapper, '09; 5th Field Co., C.E.
Hopkins, H. R., '16; Ammunition Column.
‡Hopkins, R. H., Lieut., '06; 39th Bn. (wounded in motor car accident).
Houston, F. C. A., Act.-Sgt.-Major, '19; 201st Bn.
Howes, E. A., Pte., '17; 41st Bty.
Howlett, T. F., '13; 2nd Contingent.
Hughes, B. H., Sapper, '14; 6th Field Co., C.E.
†Hughes, Chester, Lieut., '09; 6th Field Co., C.E.
Hughes, C. A., Gnr., '17; 47th Bty.
Hume, A. G., '18; U. of T. O.S. Training Co., C.O.T.C., C.E.F.
Hunter, W. H., Lieut., '17; Course at P.S.I.
Husband, L., Lieut., '16; 76th Bn.
Hutchings; W., '14; 34th Bty.
Hutcheson, F. W., Lieut., '13; Canadian Engineers.
Hall, W. T., '15; Royal Flying Corps.

Ingersoll, L. H., Sub-Flight-Lieut., '17; Royal Flying Corps.
Ingles, C. J., Major, '04; 176th Bn.
Irving, T. C., Major, '06; 2nd Field Co., Canadian Engineers.
Irwin, H., Lieut., '09; 14th Bty.
Ives, V. E., Pte., '17; No. 4 General Hospital.

Jackson, K. B., Pte., '16; 49th Bty., C.F.A.
Jack, T. B., '18; Imperial Army Service Corps.
Jarvis, R. H., Lieut., '11; Royal Naval Air Service.
Johnston, E. W., Gnr., '17; 54th Bty.
Johnson, S. H., Lieut., '18; .
Jones, L. E., Capt., '11; 2nd Bn.
†Jones, Trafford, Lieut., '06; Royal Flying Corps.
Jones, R. E., '14; C.A.S.C.
Junkin, R. L., Lieut., '13; 5th Field Co., C.E.
Jupp, E. H., Gnr., '15; 40th Bty.

Kay, J., Lieut., '14; 15th Bn.
Kayler, K. D., Sapper, '18; Divisional Signal Co.
Keefer, N. G., Lieut., '14; Imperial Army.
Keith, D. F., Major, '07; 75th Bn.
‡Kerby, H. S., Lieut., '14; Royal Flying Corps, No. 3 Squadron.
Killip, Lieut., '08; 86th Bn.
Kilmer, C. E., Lieut., '13; 19th Bn.
Kirby, R. W., Bom., '16; 53rd Bty., C.F.A.
Klinger, L. W., Lt., '07; 2nd Field Co., C.E.
†Klotz, H. N., Lieut., '09; 2nd Bn.
Knight, A. G., Lieut., '17; Royal Flying Corps (Army Branch).
Knight, J. A., Cpl., '14; 3rd Divisional Cycle Corps.
Krug, S. J., Pte., '16; Mechanical Transport, C.A.S.C.

Laing, P. A., Pte., '05; 2nd Univ. Co. P.P.C.L.I.
Langford, J. A., Lieut., '18; Divisional Signal Corps.

Latornell, A. J., Lieut., '03; 14th Bty.
†Lawless, N., Driver, '11; 5th Bn., 2nd Bde. (died of fever).
Lawrence, G. W., Lieut., '15; 81st Bn., Sig. Officer.
Lee, L. A. C., Lieut., '16; Divisional Signal Corps, C.E.
Legate, J. H., Gnr., '17; 25th Bty, C. F. A.
LePan, A. D., Major, '07; Headquarters Staff.
Leslie, A., Lieut., '13; Course at Kingston R. So. of Art.
Little, H. B., Lieut., '16; B. Reserve Bde., R.H.A.
Livingstone, A. H., '18; 5th Univ. Co., P.P.C.L.I.
Lloyd, E. G., '18; 34th Bty, C.F.A.
Lockhart, W. E., Sapper, '15; 2nd Signal Co., R.C. Engineers.
Lorimer, N. H., '14; C.F.A.
Loudon, T. R., Lieut., '05; 1st Construction O.S. Bn.
Lowrie, A. W. P., '11; 82nd Bn.
‡Lye, O. G., Cpl., '14; 2nd Univ. Co., P.P.C.L.I.

MacBeth, R. E. A., Lieut., '11; Royal Flying Corps (Army Branch).
Macaulay, G. B., '14; 1st Contingent.
Macaulay, R. V., Bom., '11; 2nd Bde., 5th Bty.
McClelland, J. P., Pte., '18; Ammunition Sub-Park, 2nd Div., C.E.F.
McClenaghan, V. S. C., Pte., '18; Canadian Engineers.
McClintock, G. A., Bom., '17; 2nd Bde., C.F.A.
McColl, J. R., Lieut., '16; 124th Bn.
McConnell, A. W., Capt., '06; Adj. 116th Bn.
McCort, C. R., Lieut., '15; No. 6 O.S. (McGill) Bty., Siege Artillery, C.F.A.
McCuaig, O. B., Q.M.S., '04; 2nd Field Co., 3rd Bde.
Macdonald, C. E., Lieut., '16; F.O. Co., C.E.
Macdonald, W. A., Pte., '14; 2nd Pioneers Bn.
MacDonald, H. H. R., '11; Royal Sussex Regt.
MacDonald, J. A., Pte., '17; 2nd Div. Cycle Corps.
McDonald, K. D., Gnr., '15; 25th Bty., C.F.A.
MacDonald, R. A., Pte., '16; 54th Bty., C.F.A.
MacDonell, I. M., Lieut., '15; Corps of Guides.
MacDougall, A. C., Lieut., '01; Canadian Engineers.
McAllister, A. L., Lieut., '93; Canadian Engineers.
McArthur, A. S., '09; 35th Bn.
McCaffrey, W. R., '15; Cycle Corps.
McCarthy, T. V., Gnr., '13; 43rd Bty.
McEachern, F. Y. P., Lieut., '09; 198th Bn.
McEwen, G. A., Gnr., '17; 47th Bty.
Macfarlane, A. H., Pte., '16; C.E.F.
Magann, G. L., Lieut., '15; Div. Ammunition Col.
McGavin, P. L., Lieut., '18; Imperial Army.
McGhie, W. G., Lieut., '11; 35th Bn.
MacGregor, A. E., '10; 142nd Bn.
McIntyre, P. F., Lieut., '18; 67th O.S. Depot Battery.
McKague, E. V., Lieut., '15; Divisional Cycle Corps.
MacKay, E. G., Lieut., '10; 91st of Hamilton.
MacKendrick, G. K., Lieut., '18; 81st Bn.

†MacKenzie, A. M., Pte., '14; M. G. Sec. 19th Bn.
MacKenzie, H. J., Lieut., '14; Canadian Engineers.
MacKenzie, J. A., Sapper, '19; Divisional Signal Co.
McKinley, F. A., Gnr., '17 25th Bty., C.F.A.
McKirdy, W. S., '11; Divisional Signal Co., C.E.
MacLachlan, W.A., Lieut., '09; 134th Bn.
Maclaren, H. J., Lieut., '18; Reserve Bde., C.F.A.
McLaren, A. J., Lieut., '11; Cameron Highlanders.
MacLean, A. P., '17; 20th Bn.
MacLennan, G. G., '10; R. F. C. (Naval Wing).
MacLeod, D. D., '10.
McMillan, J. G., Lieut., '00; Royal Engineers.
McMordie, H. C., Capt., '08;
McPherson, F. T., L.-Cpl., '16; 2nd Univ. Co., P.P.C.L.I.
McPherson, W. B., Capt., '11; Course at S. of I.
MacQuarrie, A. H., Sapper, '14; Divisional Signal Co., C.E.
McQueen, A. A., Lieut., '11; 29th Bty.
Macqueen, C. B., '19; 201st Bn.
McSloy, J. I., Capt., '10; 20th Bn.
MacTavish, H. J., Lieut., '10; R.F.A.
MacTavish, W. H., '13.
McVean, J. H., Lieut., '18.
McMurtry, L. C., '19; 67th O.S. Bty., U. of T.

Madill, H. H., Capt., '11; Instr., S. I., No. 2 Div.
Maguire, J. R., 2nd Lieut., '19; 14th West Yorkshires, B.E.F.
Malcolm, F. R., Lieut., '19; Imperial Army.
Manning, T. R., Lieut., '16; 74th Bn.
Mansell, G. R., L.-Cpl., '14; 3rd Divisional Cycle Corps.
‡Marani, F. H., Lieut., '16; 3rd Bn.
Marlatt, K. D., Capt., '08; 20th Bn.
Marshall, J. A. P., Lieut., '14; Canadian Engineers.
°Mason, D. H. C., Capt., '07; 3rd Bn., 1st Bde. (Missing).
Matthews, F. J., Gnr., '16; 25th Bty., C.F.A.
Mayberry, F. C., '17; 25th Bty.
Mendizabal, A. R., Gnr., '16; 23rd Bty., 6th How. Bde.
Merriman, H. O., Flt.-Sub-Lieut., '10; Royal N. A. S.
Merry, F. S., Gnr., '16; 25th Bty, 7th Bde.
Metcalfe, W. F., '19; Divisional Signal Corps.
Michell, A. V., '19; 67th O.S. Bty., U. of T.
Miller, D. J., Lieut., '10; 4th Field Co., C.E.
Millar, W. G., Lieut., '14; Course of S. of I.
Milligan, F. S., Lieut., '10; Imperial Army.
Millman, N. C., Lieut., '13; R.M.A.C.
Mills, G. G., Capt., '07; Artillery course.
Mills, L. G., Lieut., '11; 74th Bn.
Mills, P. H., Sgt., '14; 31st Bty, C.F.A.
Milne, J. W., Pte., '19; Divisional Signallers.
*Mitchell, C. H., Lt.-Col., '92; G.S.O. (awarded D.S.O.; La Legion d'Honneur Croix d'Officier).
Mitchell, F. L., Lieut., '17; 83rd Bn.

Mitchell, G., Lieut., '15; Imperial Army.
Mitchell, J. S., Lieut., '14; 12th Regt.
Mitchener, J. R., Lieut., '18; 4th Univ. Co., P.P.C.L.I.
Molesworth, G. N., Capt., '07; 124th Bn.
Monds, W., Lieut., '99; Canadian Engineers.
Monteith, E. M., Capt., '15; 97th Militia Regt.
Monteith, J. C., Pte., '19; 110th Bn.
Moody, F. H., Major, '08; 116th Bn.
Moorehouse, E. L., Gnr., '17; 26th Bty.
Morice, J. H., Lieut., '08; Canadian Engineers.
Morphy, J. A., Major. '11; 2nd Contingent.
Morris, B. M., Lieut., '15; 59th Bn.
Morris, W. G., '19; 67th O.S. Bty., U. of T.
Morton, C. O., Sapper, '19; Divisional Signal Co.
Muir, J. M., Lieut., '15; 127th Bn.
‡Mulqueen, F. J., Lieut., '13; 172 Mining Co., R.E.
‡Munro, A. H., Sapper, '10; 5th Field Co.
Murdie, W. C., '13.
Murton, J. C., Lieut., '11; C. F.A.
Murray, W. P., Lieut., '08: C.P. Ry. Constr. Corps.
Musgrave, J. E. T., '18; 67th O.S. Bty., C.F.A.

Nash, J. C., '10.
Neelands, R. E. K., Sgt., '07; 43rd Bty.
New, R. H., Lieut., '10; 1st F. T., C.E.
Newton, J., Lieut., '09; 67th O.S. Depot Bty.
‡Nichol, F. T., Capt., '10; 100th Bn.
Nicholson, H. R., Lieut., '17; 13th Royal Regt.
Nixon, W. H., '18; Divisional Cyclist Corps.
Norris, A. F. C., Pte., '17; 20th Bn.
Norwich, H. B., L.-Cpl., '16; 2nd Div. Cycle Corps.
Norval, T. H., '18; Divisional Signalling Co.

Oke, W. V., Lieut., '11; 35th Bn.
Ormsby, J. A. N., Lieut., '16; Eaton Machine Gun Bty.
Orr, H. W., '18; 26th Bty., C.F.A.
Oxley, A. C., Capt., '10; 2nd Field Co.

Panter, J. S., Gnr., '16; H.Q. St., 4th Bde.
Parker, A. H., Lieut., '14.
Parker, W. J., Sapper, '18; Divisional Signal Co., C.A.
Parkinson, N. F., Bom., '13; 4th Bde., 13th Bn.
Parsons, C. S., Lieut., '19; Corps of Guides.
Parsons, J. L. R., Major, '01; Gen. Steele's Staff.
Pearce, G. M., Lieut., '18; 124th Bn.
Pearson, H., Pte., Divisional Cycle Corps.
Penhale, T. W., Lieut., '18; Imperial Army.
Pepler, S. H., Lieut., '18; 124th Bn.
Peplar, S. J., Lieut., '11; Divisional Cyclist Depot.
Perry, C. V., '14; Royal Engineers.
Perry, F. M., Lieut., '98; 15th Bn.

Peterking, S. M., Sgt., '15; 41st Bty.
Pfrimmer, V. R., Gnr., '16; 25th Bty., C.F.A.
Phillips, A. M., '19; Course at R.M.C.
Phillips, W. E., Capt., '14; Royal Leinster Reg., 7th Bn.
Philp, E. B., Gnr., '19; 54th Bty.
‡Philp, W. M., Sapper, '09; 2nd Field Co., C.E.
Pollock, F. J., '19; Course at Kingston.
Powell, N. L., Lieut., '16; 208th Bn. (Signalling Officer).
Powell, W. D., Pte., '15; C.P.R. Construction Corps.
Pringle, J. E., Lieut., '16; Imperial Army.
Pullen, E. F., Capt., '05; 97th Rgt.
Purchas, C. M. G., Gnr., '17; H. Q. Staff, 4th Bde., C.F.A.

Qua, A. H., '08.

Raley, W. E., Cpl,'15., 2nd Field Co., Can. E., C.E.T.D.
Rayner, G. V., Lieut., '18; 86th Bn.
Read, F. N., Pte., '11; 2nd Univ. Co., P.P.C.L.I.
Redfern, W. B., Signaller, '08; Divisional Signalling Co.
‡Redman, W. B., Sgt., '15; 5th Field Co., R. C. Engineers.
Reed, H., Lieut., '17; Course at S. of I.
Reid, E. V., Lieut., '11; Royal Flying Corps.
‡*Reid, J. M., Lieut., '15; Seaforth Highlanders (awarded V.C.)
Relyea, J. D., Gnr., '17; Ammunition Column.
†Revell, G. E., Sapper, '99; 1st Field Co., Canadian Engineers.
Richardson, A. A., Lieut., '15; 93rd Bn.
Richardson, W. A., '11; H. Q. Staff, 3rd Bde.
Riddell, J. M., '13; Canadian Engineers.
Riley, G. W., Lieut., '19; C.A.S.C., Mechanical Transport.
Ritchie, J. E., Lieut., '13; 147th Bn. (Machine Gun Officer).
Ritchie, W. W., Lieut., '16; 35th Bn.
Robertson, A. R., Capt., '08; 169th Bn.
Robertson, J. M., Lieut., '14; 65th Royal F. Art.
Robertson, N. R., Capt., '06; 2nd Field Co.. C.E.
Robertson, W. G., '18; 67th O.S. Bty, C.F.A.
Robinson, D. A., Lieut., '18; 99th Bn.
Rogers, C. H., Lieut., '06. On Sir Max Aitken's staff.
Rolfson, O., Lieut., '06; S. O. I. at London.
Rose, H. C., Lieut., '16; Imperial Army.
Rose, J. T., Hqts. Staff, '15; 48th Battalion.
Rose, R. R., '08; Black Watch.
Ross, A. C., Sgt., '15; Course at Kingston.
Rous, C. C., Capt., '13; Engineers.
Rowe, H. M., Lieut, '15; 71st Bn.
Rutherford, F. N., '04.
Rutherford, F. S., Corp., '14; 2nd Field Co., Canadian Engineers.
Rutley, F. G., Capt., '11; 83rd Bn.
‡Rutter, G. W., Lieut., '15; 4th Canadian Mounted Rifles.
†Ryerson, G. C., Capt., '05; 3rd Bn.
Ryan, T. L., Lieut., '17; 215th Bn.
Schell, M. D., Pte., '18; 5th University Co., P.P.C.L.I.

Schwartz, G. B., '16; Capt., Cycle Corps.
Scott, A. G., Lieut., '15; 82nd Bn.
Scott, C. A., Lieut., '09; 198th Bn.
Scott, E. H., Sgt., '15, Ammunition Column. 8th Bde.
‡Segre, B. H., '09; 13th Bn., 4th Bde.
Seibert, P. T., Sgt., '19; 160th Bn.
Serson, H. V., Lieut., '05; Canadian Engineers.
Seymour, N. F., '15; 5th Divisional Signal Co.
Sharman, J. E., Lieut., '17; Royal Flying Corps.
Sharp, M. C., Gnr., '13; 2nd Bty., C.F.A.
Shaw, W. E. V., Capt., '08; 52nd Bty., C.F.A.
Sheard, Paul, Lieut., '11; C.A.S.C., 3rd Divisional Train.
Sheppard, A. C. T., Cpl., '07; 4th Field Co., Canadian Engineers.
Sheppard, H. L., Lieut., '14; Course at Kingston.
Sherman, N. C., Capt., '10; Canadian War Purchasing Commis'n.
Shier, W. G., Gnr., '15; 25th Bty., 2nd Bde., C.F.A.
Shoebottom, L. R., Lieut., '17; .
Sills, C. P., Gnr., '11; 43rd How. Bty., C.F.A.
Sime, A. W., Lieut., '14; 35th Bn., M. G. Sec.
Simmers, J. A., Pte., '18; 2nd Univ. Co., P.P.C.L.I.
Simmons, J. F. L., Gnr., '15; 4th Bde., C.F.A.
Simpson, B. N., Lieut., '14; C. F. A.
Simpson, F. W., Sapper, '18; Divisional Signal Co.
Sinclair, C. E., Lieut., '14; Royal Irish Fusiliers.
‡Sinclair, I. M. R., Capt., '17; 13th Bn.
Sinclair, R. B., Lieut., '15; Royal Field Art., 3 B. Res. Bde.
Smith, A. H., Lieut., '99; 2nd Canadian Pioneers Bn.
Smith, C. H., '17; 25th Bty., 7th Bde., C.F.A.
Smith, D. A., Cpl., '04; 5th Bn.
Smith, F. L., Gnr., '10; 13th Bty., 4th Bde.
Smythe, Conn, Lieut., '16; 40th Bty., 7th Bde.
Smythe, G. M., Capt., '14; 76th Bn.
Sneath, Roy G., Lieut., '11; 3rd Div'l Canadian Engineers.
Snow, G. B., Lieut., '16; 134th Bn.
Souter, J. M., Lieut., '18; 133rd Bn.
Spencer, A. C., Lieut., '07; 2nd Can. Divisional Cavalry.
Standing, R. O., Pte., '14; 3rd Divisional Supply Col., C.A.S.C.
Stalker, C. H., Lieut., '18; G.G.B.G.
Steele, A. L., '10; A.S.C., Canadian Engineers.
Steele, W. A., Lieut., '15; Divisional Signalling Officer.
Steers, F. P., Lieut., '14; Canadian Engineers.
Stevenson, C. W. G., Gnr., '17; 29th Bty.
Stephenson, G. E., Sapper, '17; Divisional Signal Co.
Stewart, A. E., Lieut., '11; Signal Co., C.E.
Stewart, D. L. N., '05; 20th Bn.
Stewart, H., Pte., '16; 20th Bn., M. G. Sec.
Stock, J. J., Sapper, '08; Signal Co.
Storms, D. H., Lieut., '15; 8th Bty.
Stratford, G. S., Pte., '16; 2nd Univ. Co., P.P.C.L.I.
Strathy, J. M., Sapper, '13; Signal Co., C.E.

Stuart, H. B., Lieut., '08; 2nd Canadian Pioneers Bn.
Sutcliffe, C., Capt., '10; 77th Bn.
Sutherland, D., Lieut., '13; 110th Bn.
Swinnerton, A. A., Pte., '16; Divisional Cycle Corps.
Swinnerton, A. F. R. W., Lieut., '16; 166th Bn.
Szammers; Cpl., '11; 2nd Can. Pioneers Bn.

Tate, H. W., Capt., '09; 2nd Canadian Pioneers Bn.
Taylor, F. H., Lieut., '18; 204th Bn.
†Taylor, G. B., Lieut., '14; 15th Bn.
Taylor, J. S., '14; Motor Bty.
Taylor, R. E., '16; 2nd Contingent.
Ternan, R. E., '10; British Admiralty.
Thomas, A. M., Lieut., '16; Royal Flying Corps (Naval Wing).
Thomas, G. C., Lieut., '11; Imperial Army.
Thompson, C. C., Lieut., '17; 124th Bn.
Thompson, H. G., Pte., '18; 135th Bn.
Thompson, R. J., '19; Divisional Cycle Corps.
Thornley, J. H., Major, '08; 33rd Bn.
Tillson, L. B., '15; Imperial Army.
Tilston, J. A., '14; Canadian Overseas Construction Co.
Tindale, C. E. W., Gnr., '17; 48th Bty.
Tobin, K. E., '16; 1st Contingent.
Tom, J. A., Gnr., '15; 26th Bty, 7th Bde, C.F.A.
Torrance, R. D., Lieut., '11; 34th Bn.
Torrance, T. E., Lieut., '13; Course at Royal School of Art.
Trebilcock, J. A., Lieut., '15; 4th Bde., R.F.A.
Trees, A. G., Lieut., '09; Course at S. of I.
Tremayne, J. E., Lieut., '16; 127th Bn.
Twidale, E. A., Lieut., '14; Imperial Army, R.F.A.
Trywhitt, R., Lieut., '16; 215th Bn.
Tracy, G. F., '18; Divisional Signalling Co.
Tough, W. G., Lieut., '11; 14th Bty.

Utley, R. A., Pte., '10; 2nd Univ. Co., P.P.C.L.I.

°VanAllen, K. M., Lieut., '10; R.N.A.S.
VanNorman, C. P., Lieut., '08; 127th Bn.
Vaughan, O. D., Lieut., '17; C.A.S.C.
Verity, M. F., Lieut., '14; 125th Bn.
Vernon, A. A. H., Lieut., '18; 10th East Surrey Regt.
†VanSittart, G. E., Major, '05; 13th Bty., C.F.A.

Wait, G. E., Lieut., '17; 12th York Rangers, 220th Bn.
Walcott, W. D., Pte., '11; 5th Univ. Co., P.P.C.L.I.
Wallace, H. D., Lieut., '17; 234th Bn.
Wallace, H. D. M., Lieut., '14; Aviation Corps.
Wallace, J. S. M., Gnr., '17; 67th O.S. Bty., U of T.
Wallis, H. M., L.-Cpl., '16; Aide to Brig.-Gen. Wallis, 16th Bn.
Wallis, J. H., L.-Cpl., '15; 16th Bn. (Home on sick leave).
Ward, A. L., Sgt., '15; H.Q. Staff, No. 2 Div., under Major Dunn.

Ward, H. G., Sapper, '19; Divisional Signal Co.
Ward, John W., Gnr., '17; 25th Bty., 7th Bde.
‡Watson, M. B., Lieut., '10; Royal Engineers, Imperial Army (wounded in motor car accident).
Watts, E. M., Major, '11; 198th Bn.
Watts, R. E., Lieut., '13; 84th Bn.
Webster, D. B., Lieut., '15; R.C.H.A.
Webster, H., Lieut., '13; R.F.A.
Weldon, H. S., Lieut., '18; H.Q. Staff.
Wells, A. R., Lieut., '16; Imperial Army.
West, A. M., Lieut., '08.
West, C. W., Lieut., '15; Course at S. of I.
Whaley, A. B., Lieut., '16; R.F.A.
Wheelock, C. H., Pte., '16; 35th Bn., M. G. Sec.
Whiteside, J. L., Lieut., '10; 46th Bn.
Whitley, P. L., '14; U. of T. O.S. Training Co., C.O.T.C., C.E.F.
Wigle, G. B., Lieut., '18; C.A.S.C.
Wilcocks, W. S., '15.
Wilkes, G. H., Lieut., '11; R.E.
Willey, C. M., Lieut., '18; G.A.R., Imperial Army.
Williams, G. K., Sub-Flt.-Lt., '10; Mech. Supt., Air Training School at Detling.
Williams, J. N., Gnr., '15; 26th Bty., 7th Bde., C.F.A.
Williams, P. E., Lieut., '18; 124th Bn., Signal Officer.
Williams, R. E., Gnr., '16; Int. Corps, C. Fd. Art.
Willmott, L. E., Lieut., '17; 170th Bn.
‡Wilson, Dutch, '15; Sgt., 15th Bn.
Wilson, J. N., Lieut., '06; Course at Kingston.
Wilson, J. S., Gnr., '16; 26th Bty., 7th Bde.
Wilson, L. R., Lieut., '09; C.P.Ry. Construction Corps.
Wilson, W. S., Lieut., '16; 147th Bn.
Wimperly, C. C., Lieut., '18.
Withrow, W. J., Lieut., '90; 2nd Canadian Pioneers Bn.
Wood, F. A., Lieut., '18; G.G.B.G.
Wood, H. A., Lieut., '15; Royal Flying Corps.
Wood, N. C., Lieut., '17; Imperial Army.
Wood, R. F. B., Capt., '13; 123rd Bn.
‡Worthington, A. N., Major, '13; 169th Bn.
Wright, A. J., Sgt., '13; 74th Bn.
Wright, W. J. T., Lieut., '11; 67th O.S. Depot Bty.
Wylie, W. H., Lieut., '11; Canadian Engineers.
Wyman, H. K., Gnr., '11; 25th Bty., 8th Bde.

Youell, L. L., Lieut., '16; 43rd How. Bty., C.F.A.
Young, C. R., Capt., '03; Instr., S. of I., No. 2 Division.
Young, J. F., Gnr., '17; 25th Bty., 7th Bde. C.F.A.
Young, T. J., '18; 25th Bty., 7th Bde., C.F.A.

NOTE.—Additions and corrections to this list will be appreciated by Prof. A. T. Laing, secretary of the Faculty.

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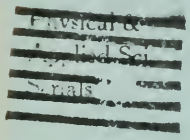

Engineering

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